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ORIGINAL ARTICLES.

I.—Additional Note on *Drepanaspis Gemündenensis*, Schlüter.

By Dr. R. H. Traquair, F.R.S., F.G.S.

In my "Notes on *Drepanaspis Gemündenensis*, Schlüter," published in the Geological Magazine for April, 1900 (pp. 153–159), I described a paired plate of a trapezoidal form occupying a position on each margin of the under surface of the head, a little behind the mouth, and to which I gave the name 'sensory' plate, as it is perforated by an opening which, if not orbital, evidently marks the place of an organ of sense of some sort. With this opening I also identified a depression seen in some specimens in a similar position on the dorsal aspect, and came to the conclusion that its position was *marginal*, being seen in some specimens on the ventral and in others on the dorsal surface of the head. I was also much puzzled to find that in some specimens this pit or depression seemed to have a *floor*, covered with tubercles like those of the rest of the surface, a condition which apparently militated very decisively against the idea of its being an orbit.

Increase of material has enabled me to clear up this point at last, and to rectify my restored figures accordingly.

I found, namely, that when the appearance in question is seen on the ventral aspect (*x*, Fig. 2), it is, in all cases, an actual perforation, but when seen on the dorsal it is a mere depression surrounded by a slightly elevated margin and provided with an imperforate tuberculated floor. Isolated specimens of the sensory plate show also that it was not reflected round the lateral margin of the head (it is not so at least in the fossils), and when I obtained a view of the plate from its *internal* surface, the perforation was found to be surrounded by a thickened ring-like margin. Here,

then, is an explanation of the imperforate pit seen on the dorsal surface. For it is now quite clear that this appearance is caused by one of the dorsal plates being *squeezed down upon* the aforesaid thickened ring-like margin of the round opening in the sensory plate, which accordingly *shows through*, although the opening itself is on the ventral surface, as shown in Fig. 2, *x*.

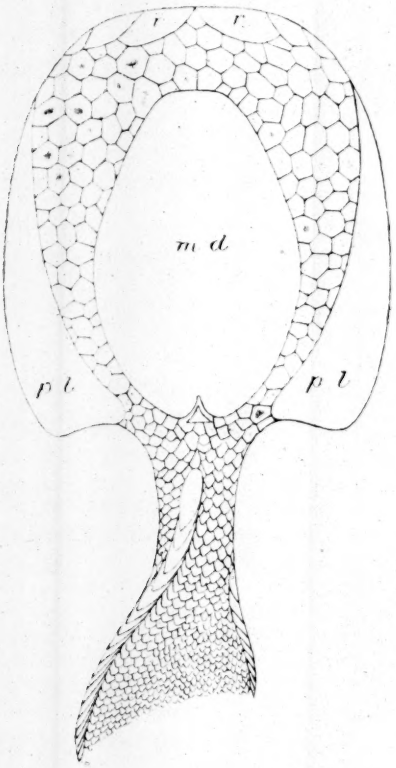


FIG. 1.—*Drepanaspis Gemündenensis*, Schl. Restored outline of the dorsal aspect, the surface ornament omitted, and the tail twisted round so as to show the caudal fin in profile. *m.d.* median dorsal plate; *p.l.* postero-lateral plates; *r.* rostral plates.

Consequently the object *x* is an actual opening which perforates a special plate (sensory) belonging to the ventral aspect of the head, and the appearance of a pit on the dorsal aspect is due to pressure during fossilization, and should be deleted from the restoration, as I have done in Fig. 1.

That this opening, which, though perforating a plate belonging to the ventral surface, lies just within the lateral margin of the head,

corresponds to the supposed orbit of *Pteraspis*, does not, I think, admit of any reasonable doubt.

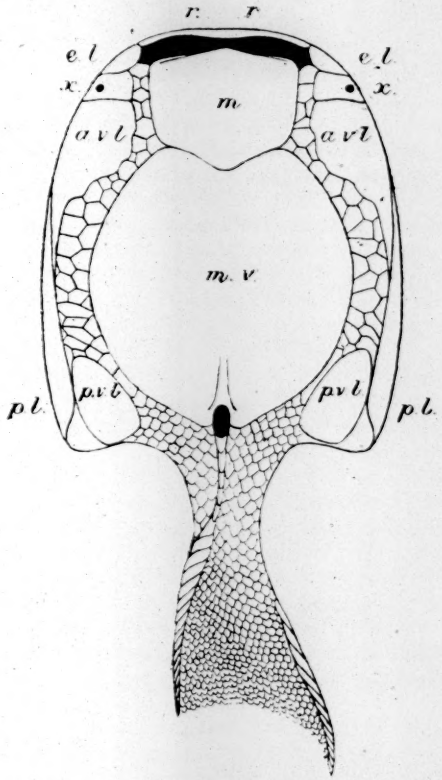


FIG. 2.—Restored outline of the ventral aspect of *Drepanaspis Gemündenensis*, Schl. Surface ornament omitted, and the tail twisted round so as to appear in profile. *r.* rostral or upper labial plates; *e.l.* external labial plates; *x.* sensory openings (orbits ?); *a.v.l.* anterior ventro-lateral plates; *m.v.* median ventral; *p.v.l.* posterior ventro-lateral; *p.l.* postero-lateral or cornual plates. Mouth and supposed cloacal opening indicated in black.

II.—Preliminary Note on some Recently Discovered Extinct Vertebrates from Egypt. (Part III.)

By Chas. W. Andrews, D.Sc., F.G.S., British Museum (Nat. Hist.).

MORE detailed examination of the material collected by Mr. Beadnell and myself in the Fayûm in 1901 has led to the recognition of two additional species of *Mœritherium*, and has made it clear that the Sirenian belongs to a distinct genus, which presents some characters of much interest and is nearly related to *Prototherium* (*Halitherium*) *veronense*, described by Zigno from remains found in beds of Upper Eocene age at Monte Zuello in Northern Italy.

It is desirable to give brief preliminary notes on these species, the full description of them being reserved for the monograph on the whole collection which is being prepared.

Mœritherium gracile, sp.n.

This species is a smaller and rather more lightly built form than *M. Lyonsi*. The skull is more elongated in proportion to its width, the palate is narrower, and the squamosal region of the side of the skull is swollen so as to form a slight rounded protuberance, owing apparently to the great development of the diploe in the squamosal and its consequent thickening. The occipital surface also presents some differences from that of *M. Lyonsi*, particularly in the comparative narrowness of the escutcheon-shaped plate formed by the supra-occipital and in the smaller extent of the periotic that is exposed.

The teeth present the most easily recognized peculiarities. The cheek-teeth are much smaller than in *M. Lyonsi*. They are arranged in perfectly straight lines, the right and left series being almost parallel with one another; the palate is very narrow.

The chief points in which the tooth structure is distinguished from that seen in *M. Lyonsi* are:—

(1) In p.m. 2 and p.m. 3 the shelf-like surface on the postero-internal border is wanting, and in p.m. 3 at least there seems to have been a distinct postero-internal cusp in its place, but none of the specimens are very well preserved.

(2) The cingulum is much more strongly developed than in *M. Lyonsi*, and the enamel is marked by a peculiar sculpture consisting of fine irregular vertical fluting. The form and arrangement of the incisors and canines are as in *M. Lyonsi*.

The dimensions of the upper teeth are:—

	Length.	Width.
p.m. 2	22 mm.	18 mm.
p.m. 3	20 ,,	23 ,,
p.m. 4	20 ,,	21 ,,
m. 1	23 ,,	23 ,,
m. 2	24 ,,	25 ,, (approx.)
m. 3	28 ,,	24 ,,

Total length of p.m. and m. series	137 mm.
,, ,, p.m. series	62 ,,
,, ,, m. series	75 ,,

In *M. Lyonsi* the length of the p.m. and m. series is approximately 160 mm. and of the p.m. series is 74; and in the width of the teeth the difference between it and *M. gracile* is still greater: thus in *M. Lyonsi* the width of p.m. 3 is 27 mm. and m. 2 27, while in the present species the same teeth measure 20 and 24 respectively.

Mœritherium, sp.

The other species is known only by a nearly complete vertebral column, differing from that of *M. Lyonsi* both in its larger size and in many small structural points. In the absence of any well-preserved remains of the skull and teeth of this form it seems advisable for the present to refrain from giving it a name until

further material is available. The occurrence of these three species of *Mœritherium* in a small area seems to point to the conclusion that these animals were a dominant type of the fauna of the region, and possibly it will be found that they form a group divisible into several genera.

Eosiren libyca, gen. et sp. nov. (Figs. 1–3.)

Two species of Sirenians have already been discovered in the Eocene beds of Egypt, both being from the white Mokattam Limestone of Cairo. Of these one was described by Owen under the name *Eotherium ægyptiacum*,[1] on the evidence of a natural cast of the cranial cavity; the other was described by Filhol from three lower molars, and was named *Manatus Coulombi*.[2] Since both these species, if indeed they are distinct, occur on nearly the same horizon as the specimens from the Fayûm, it will be necessary to consider whether the latter may not be identical with one or both of them.

According to Filhol the lower molars, which he made the types of *Manatus Coulombi*, differ only in small details from those of *Manatus australis*, and he did not think that they could belong to *Eotherium ægyptiacum*, because the brain of that species indicates a much more primitive type of Sirenian than the living genus. In any case, whether he was right in referring his species to *Manatus* or not, the dentition of the Fayûm species is widely different from that of the Manatees, and therefore it must be assumed to be distinct from *M. Coulombi*.

In the case of *Eotherium ægyptiacum*, as already mentioned, the type is the cast of the brain-case, and fortunately it has been possible to make a similar cast from one of our specimens, so that the two forms are directly comparable. Dr. Elliot Smith[3] has examined these casts, and he has come to the conclusion that the two forms are distinct.

It thus appears that our species is distinct from those previously described from Egypt, and its relations must be sought elsewhere. From the Eocene of Italy Zigno has described several Sirenians, the best known being first named *Halitherium veronense*,[4] but afterwards referred by the same writer to a new genus, *Prototherium*,[5] which, however, he never fully defined, merely stating that it included Eocene Sirenians in which the mandible bears a prominent posterior (surangular) process. In many respects, e.g., in the general form

[1] Owen: Quart. Journ. Geol. Soc., vol. xxxi (1875), p. 100. The generic name *Eotherium* had been previously employed by Leidy in 1853 for a genus of Perissodactyla, and therefore, strictly, the name *Eotheroides* suggested by Palmer (*Science*, n.s., vol. x, 1899, p. 494) should be employed for this Sirenian, but in the present paper I prefer to continue to use the name by which it is best known.

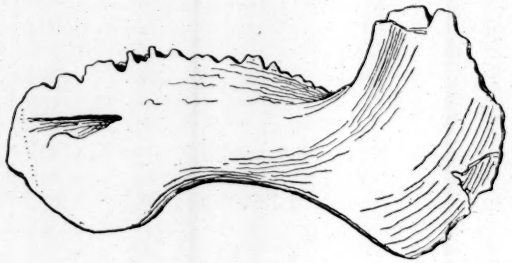
[2] Bull. Soc. Philomathique de Paris, ser. vii, vol. ii (1878), pp. 124–5.

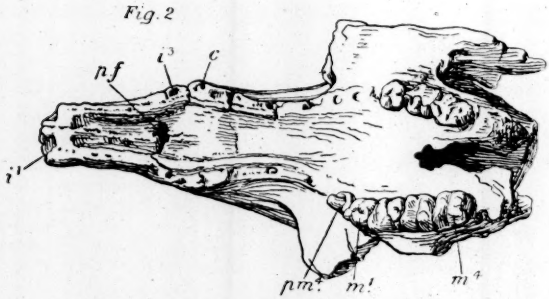
[3] Dr. Elliot Smith's descriptions of these and other brain-casts from the Fayûm will be published in the proposed monograph on that district.

[4] Zigno, "Sirenii fossili trovati nel Veneto": Mem. Inst. Veneto d. Sci., vol. xviii (1875), p. 445.

[5] Zigno, "Quelques Observations sur les Sirenians fossiles": Bull. Soc. géol. France, vol. xv (1887), p. 731.

of the skull, particularly of the rostrum, *Prototherium veronense* seems to be closely similar to the Fayûm form, but since it is very doubtful on the one hand whether it possessed canines and posterior incisors, and on the other, whether the process on the mandible which characterizes it, is present in the Egyptian form, it is best to establish a new genus for the reception of the latter.





Skull and mandible of *Eosiren libyca*. One-third natural size.

Figs. 1 and 2.—Skull. Fig. 3.—Mandible.

p.f. palatine foramen; i^1, first incisor; i^2, i^3, second and third incisors; *c*, canine; $p.m.^4$ last premolar; m^1, m^4, first and fourth molars.

The name *Eosiren* may be adopted for this genus, which will include Eocene Sirenians in the upper jaw of which the anterior

incisors (i^1) are modified to form a pair of downwardly directed tusks, and there are also one or two pairs of small laterally placed incisors (i^2, i^3) near the premaxillo-maxillary suture. Canines (c) were present; both these and the posterior incisors were probably shed early in life. The upper cheek-teeth are eight in number, consisting of four single-rooted teeth (premolars) and four double-rooted molars, the crowns of which are bilophodont, each ridge being distinctly composed of two tubercles. (Figs. 1, 2.)

The downwardly deflected symphyseal region of the mandible is greatly thickened and very massive; it bears the alveoli of four pairs of teeth, apparently the incisors and canines. The anterior pair of these alveoli is comparatively shallow, and in all probability the teeth were lost early, this region being covered by a horny sheath. There were probably three single-rooted and five double-rooted cheek-teeth; but this is uncertain owing to the want of well-preserved specimens. There are indications that a replacement of the molars from behind was already established in this early form, at least in the mandible. (Fig. 3.)

The vertebral column is much like that of *Halitherium*, and the scapula is characteristically Sirenian in form, having a backwardly curved, sickle-shaped blade. The rudimentary os innominatum is similar to that of *Halitherium Schinzi*, but the acetabulum is more strongly defined. The species from the Fayûm may be called *Eosiren libyca*. The dimensions of the type skull are :—

	mm.
Extreme length in straight line	290
Width at occipital condyles	75
Width of foramen magnum	34
Height of foramen magnum	22
Width between supra-orbital processes	87
Width of cranial roof between the temporal fossæ ...	47
Width of snout in front of external nares	45
Length of dental series from canine to last molar... ...	114
Length of molar series	56
Length of external narial opening	64
Width of external narial opening	30

The mandible figured was not associated with the skull, but was found on the same horizon and in the same locality.

It is interesting to note that the alveoli for the posterior incisors and the canines are not borne on the alveolar border of the upper jaw, but seem to have been thrust somewhat outwards on to the facial surface, probably through the development of the horny plate which formed the actual biting surface of the anterior portion of the jaw. It is remarkable that, except in the presence of posterior incisors and canines, this early (Middle Eocene) Sirenian is scarcely at all more generalized than the later *Halitherium*, and it appears that the Sirenia must have branched off from their parent stock at an extremely early period. In some respects, particularly in the structure of the teeth and of the humerus, there is a certain similarity with *Mœritherium*, and it seems not improbable, therefore, that the relationship between the Sirenia and the Proboscidea suggested by Blainville and others may have a real existence.

III.—Geological Age of the Ogasawara Group (Bonin Islands) as indicated by the occurrence of Nummulites.

By S. Yoshiwara, Science College, Imperial University, Tōkyō, Japan.

In the geotectonics of the Japanese Islands, neo-volcanic eruptions in chains parallel to the direction of their elongation play an important part. Dr. Harada[1] has counted three of them on the north, and four on the south of Kwantō, where the mountain-systems of northern and southern Japan are confluent. Besides, there are three chains across Japan. They are (1) the Kirishima chain running from N.W. to S.E., in the southern part of Kyushū; (2) the Chishima chain in Hokkaidō running from N.E. to S.W.; and (3) the Fuji chain forming the boundary of northern and southern Japan (Fig. 1). In a part of the Myokō volcanic group forming the northern extremity of the last important chain, there are the volcanoes of Onigajō, Myokō, Kurohime, and Iijuna, all of which have erupted, according to Mr. Yamazaki, through the Neogene Tertiary (probably Miocene). The southern continuation of this group is that of Yatsugatake, consisting of about nine volcanoes. Further on the south stands Mt. Fuji, formed in the Pliocene or Diluvium, like its southern neighbour Ashitaka-yama, which, according to Mr. Hirabayashi, more early reposed. In the Hakone and Atami volcanoes, also in the Fuji chain, eruption took place, according to him, first in the Pliocene epoch, but chiefly in the Diluvial. The Izu peninsula, a part of this chain, described geologically by Mr. Ishihara, has several volcanoes — Necogoe, Jaishi, Amagi, Daruma, Sukumo (?), and Ajiri (?). On the southern part of the Fuji chain lying in the sea, there are found the small islands collectively called Izu-shichitō. Tracing further southwards, we have Aoga-shima,[2] Bayonnaise Rocks, Smith's Island, Tori-shima (Ponafidin Is.), Lot's Wife Rock, the Ogasawara group (Bonin Islands), the Sulphur Is. group (Volcano Islands), and the islands of the Mariana or Ladrone group, all of which, being of neo-volcanic origin, had been until recently regarded as a continuation of the Fuji chain (Fig. 1).[3] However, in order to study their true geological relations, I spent about one month (July to August, 1901) in visiting all the islands of the Ogasawara group, except the Muko-jima sub-group, and I came to quite a different conclusion.

The Ogasawara group is divisible into three sub-groups. The northern part is the sub-group of Muko-jima (Parry gr.), containing Kater Island together with Nakōdo-jima, Yome-jima, Kitano-shima, Harino-iwa, etc. The middle one is that of Chichi-jima, comprising Chichi-jima (Peel Is.), Ani-jima (Buckland or Hog Is.), Otōto-jima (Stapleton or North Is.), Higashi-jima (Sandy Beach Is.), Nishi-jima (Little Goat Is.), Minami-jima (Long Is.),

[1] Harada: "Die Japanischen Inseln," 1890.

[2] *Shima* (pronounced *Jima* in combination) means island or islands.

[3] Harada: "Die Japanischen Inseln," 1890. Kikuchi, "On Pyroxenite Compounds in certain Volcanic Rocks from Bonin Island": Journ. Coll. Sci. Imp. Univ., vol. iii (1890).

Hitomaru-jima (Charles Little Is.), Hyotan-jima (Pihi Is.), Yagi-jima (Goat Is.), and Kitano-shima (Fig. 2). The southern part is the sub-group of Haha-jima (Barley or Coffin gr.), with Haha-jima (Hillsborough Is.), Ane-jima (Perry Is.), Imōto-jima (Kelly Is.), Mei-jima, Hira-shima, Mukō-jima (Plymouth Is.), Maru-shima, Futago-jima, Matsunbōshi, and others (Fig. 3). All the islets of the Ogasawara group are arranged in a line running 27° 40′ N. to 26° 38′ N. Far to the south-west of Haha-jima there is another group called Sulphur Is. (Volcano Islands), comprising Kita-iwō (San Alessandro Is.), Iwō (Sulphur Is.), and Minami-iwō (San Augustino Is.), (Fig. 1). All the islets of the Ogasawara group show the same geological formation. The chief rock in the Chichi-jima sub-group is agglomerate tuff alternating with andesite lava. On the island of Chichi-jima, a very fine tuff is exposed on the west of Omura and the north of Mikazuki-yama, where we rarely find thin strata of shale. The volcanic rock is almost all augite-andesite. That on the north of Futami harbour (Port Lloyd) in Chichi-jima and on Ani-jima and Otōto-jima is black-coloured with resinous lustre, sometimes changed to a green weathered mass, and is often broken by fissures into large polyhedral fragments. Beautiful crystals of heulandite, apophyllite, analcime, and chabasite are found as druses only in this black andesite. The same rock is also found on the southern coast of Chichi-jima and north of Hatsune-ura on the east coast of the same islet. The andesite exposed on Haha-jima and Kominato in Chichi-jima is blackish-grey to light-grey, with gas pores filled with white silica. Specimens from Ōgiura, Kitafukurozawa, north-east of Tatsumi-ura, and the neighbourhood of Taka-yama in Chichi-jima, belong entirely to vitro-andesite. Mr. Suzuki[1] has described serpentine from Kurose in Otōto-jima. Numerous liparite dykes pass from the south-western corner of Ani-jima to the north-eastern of Chichi-jima. The same rock is not found elsewhere on the Ogasawara and Sulphur Is. groups. In the Haha-jima sub-group we find, besides the predominant agglomerate tuff, several varieties of andesite. Vitro-andesite is frequently met with near Oki-mura and in the neighbourhood of Chibusa-yama in Haha-jima. Andesite having large phenocrysts are principally exposed on the west of a line drawn from Kita-mura to Big Bay in Oki-mura. Andesites are also found in the isolated islets of Imōto-jima and Mei-jima. Generally speaking, the Haha-jima sub-group has the same structure as that of Chichi-jima. *These two sub-groups are typical submarine volcanoes, which sent out numerous streams of lava by subsequent eruptions after frequent periods of repose.* With regard to the sub-group of Muko-jima, which I could not personally visit, I have obtained a series of rock-specimens. The islands in this group, situated in the same direction as the Chichi-jima and Haha-jima sub-groups, judging by the specimens, must show the same geological structure.

[1] Suzuki, "Petrography of the Bonin Islands" (in Japanese): Bull. Geol. Soc. Japan, vol. i, No. 1 (1885).

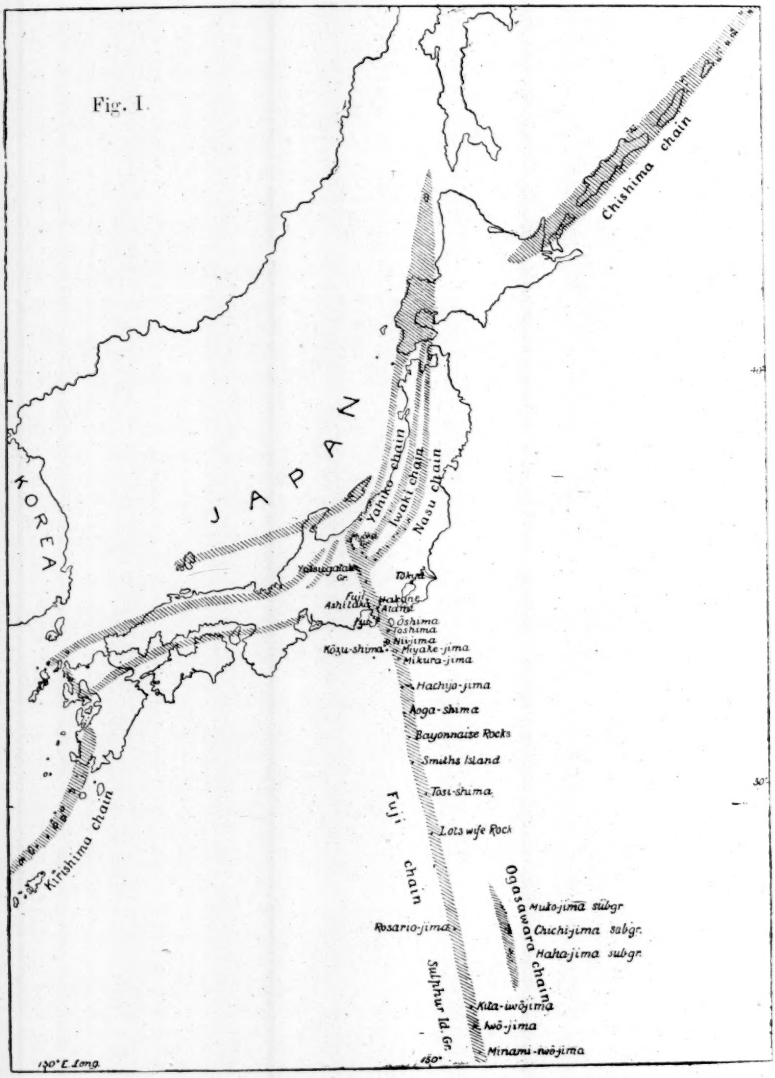
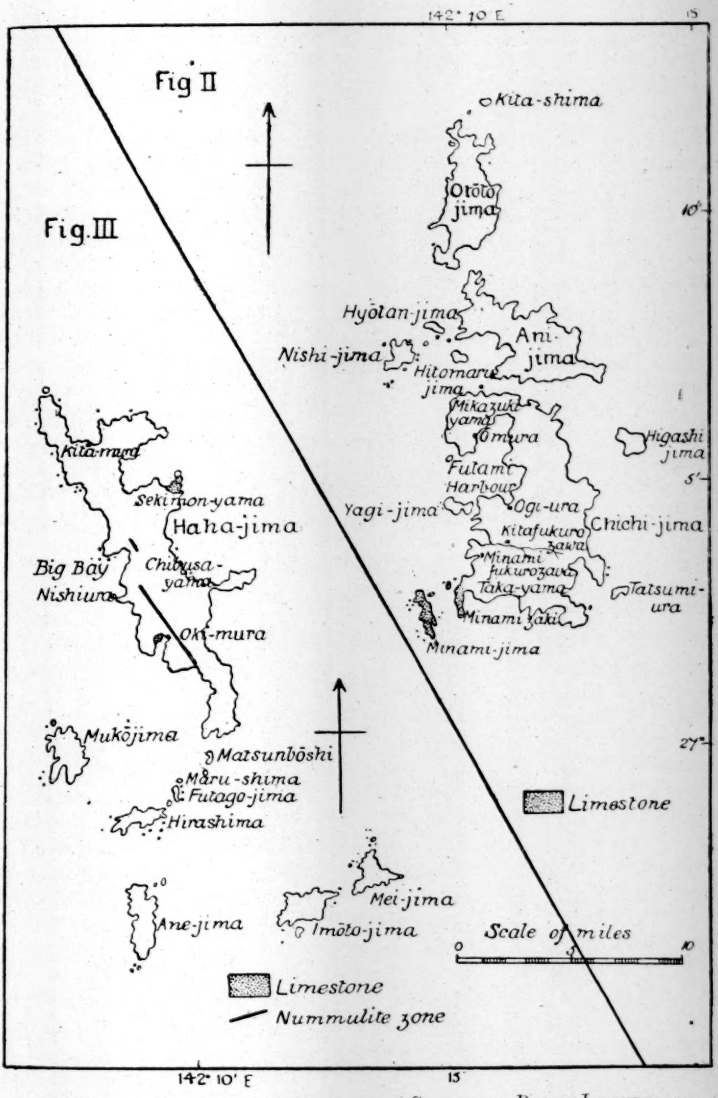


FIG. I.—TO ILLUSTRATE THE NEO-VOLCANIC CHAINS OF THE JAPANESE ISLANDS. The shaded portions indicate lines of volcanic disturbance.



Maps of Parts of the Ogasawara Chain, or Bonin Islands.

Fig. II.—The Chichi-jima Sub-group.
Fig. III.—The Haha-jima Sub-group.

A special interest is connected with the *Nummulites*, which are abundantly found in the tuff and agglomerate tuff of the Ogasawara group. A single specimen of Nummulite was brought in 1899 to Mr. Wakimizu by a student of the Agricultural College, but at that time the relation to the volcanic rocks of the group was not yet known, nor *the occurrence of Nummulites in Japan* discussed by Japanese geologists; thus the subject was one of special interest in my observations. The *Nummulites* are found, as far as I know, only on the south-western side of Haha-jima, viz., at Nankinyashiki, Cocoa-nut beach, Rōsu-dani, Shizuka-dani, Ichinohashi, Sannohashi, and Nenbutsu-tōge. The Foraminifera-bearing tuff of these localities, except the last, belongs to the same horizon and shows a westerly dip (Fig. 3). In some places the rock is found at a few hundred feet above the sea-level, with a thickness of from 30 to 40 feet. That of Nenbutsu-tōge, only, is found at a height of more than 600 feet, and its relation to that in other localities has not yet been ascertained.

Our *Nummulites* are of two distinctly different sizes. Millions of the smaller form a rock closely cemented together with a tufaceous material. Their diameter and thickness scarcely exceed 5·5 mm. and 2·6 mm. respectively. They are identical with *Nummulites baguelensis* of Verbeek[1] from the Eocene of Java. The larger specimens are again separable into flatter and thicker forms. The thicker ones are identical with *Nummulites javanus*, Verbeek,[1] from the Eocene of Java, and attain a thickness between those of var. β and γ of Verbeek. The flatter ones, which belong to either a variety of the other form or to a quite different species, are very large; the largest collected by me has a diameter of 60 mm., and is probably one of the most gigantic *Nummulites* in the world. On the same horizon as that of the characteristic Foraminifera I found in the tuff of Nishi-ura, near the above-mentioned localities, *Schizaster*, *Pecten*, a large *Nerita* (somewhat allied to *N. schmedeliana*, Chem., abundant in the Eocene Nummulitic formation of India), besides less numerous forms as *Voluta*, *Cardium*, *Tapes*, *Natica*, *Dentalium* (?), *Vermetus*, *Trochus* (?), another species of *Nerita*, two forms of *Ostrea*, and many species of corals. I have collected, besides, complete specimens of three species of *Lithothamnium* from the same place. In the tuff of Oki-mura, lying a little below the strata of Nummulite-tuff, there are many forms of sharks' teeth, representing at least three different species of *Lamna*, together with a few specimens of *N. baguelensis* and *N. javanus*. It is very noticeable that the Nummulite-tuff is evidently intercalated in the lava-sheets or agglomerate tuff, and some large andesite blocks are sometimes enclosed in the tuff as at Rōsu-dani. In Haha-jima I could not find any sign of difference of age to subdivide the rocks of volcanic origin. Thus, all the andesites as well as tuffs of Haha-jima and the other islands of the Ogasawara group must have been formed in the Eocene epoch.

[1] Verbeek et Fennema: "Description géologique de Java et Madoura," t. ii (1896).

Andesite and tuff are the chief rocks composing the Ogasawara group. The latter are always inclined in various directions, showing great disturbance after their formation. We find great limestone exposures, resting in quite horizontal layers, in some parts of the Haha-jima and Chichi-jima sub-groups. The high hill of Sekimon-yama in Haha-jima is entirely formed of this rock, which is besides found in separate areas at Oki-mura and Akaiwa (Sankaku-iwa). In Chichi-jima the same limestone forms the southern point of land called Minami-jaki, as well as Minami-jima and many neighbouring rocks. The limestone is always in elevated places, especially that of Sekimon-yama, which is found at a height of about 800 feet above sea-level, and forms two successive vast terraces along a hill of agglomerate tuff which is about 100 feet higher than the limestone plateau. Here the limestone extends towards the interior for a few miles, and was originally an elevated coral reef. *Lithothamnium*, Bryozoa, and corals are predominant in the limestone. Numerous *Orbitoides* are also found in the same rock at several places. In Minami-jima I found at least three species, one of which is very thin, with the very large diameter of 47 mm. In Oki-mura in Haha-jima, at least three species of small *Orbitoides* were also collected. A few individuals of one small species have been taken from the limestone of Minami-zaki. All the *Orbitoides* above mentioned belong to *Lepidocyclina*;[1] some of them are identical with those from the Miocene of Java described by Verbeek. Thus the submarine volcanic eruption of the Ogasawara group began in the Eocene epoch, and had already ceased before the Miocene. This old volcanic chain must therefore be separated from the Fuji chain, which is younger Neogene or partly even still younger in origin. For the old chain I propose the name of "Ogasawara chain." No indisputably Eocene volcanoes corresponding to the age of this chain have yet been found in Japan, especially near the Fuji chain.

The Fuji chain certainly extends as far as Hachijō-jima. On its south there are, in a line with the Fuji zone, the islets of Aogashima, Bayonnaise Rocks, Smith's Is., Tori-shima[2] (Ponafidin Is.), and Lot's Wife Rock, all of which are composed of andesite rock. No land is found between the last islet and the Ogasawara group. When we examine on a map the relative positions of the islands near the Ogasawara group, we find them in two rows. The first row passes from the sub-group of Muko-jima to that of Haha-jima in a line from north to south, at the longitude of about 142° E. The other islets, viz. Rosario-jima on the west of the Ogasawara

[1] Localities of *Orbitoides* in Japan had been confined to Nakakosaka in Province Kōtsuke and Kawaguchi in Province Kai, prior to my journey to Formosa and Riukiu (Loochu) Islands in 1899. Specimens found in Nakakosaka have been determined by Jones as *O.* (*Discocyclina*) *dispansa*, Sow., but afterwards as *Lepidocyclina* by Verbeek. I collected numerous specimens from the limestone in Iriomote-jima in Riukiu (Journ. Coll. Sci. Imp. Univ. Tōkyō, vol. xvi, pt. 1, art. 2, 1901). By my latest researches I am convinced that all these *Orbitoides* of the above three localities belong to *Lepidocyclina*. Besides, Messrs. R. B. Newton and R. Holland found a species of *Lepidocyclina* (*O. Verbeeki*, Newt. & Holl.) in a slide of Formosan limestone (Journ. Geol. Soc. Tōkyō, vol. vii, No. 81, 1900).

[2] Spelt Tosi-shima on map, Fig. 1, p. 298.

group and the islands of the Sulphur Is. group, all of which are also of neo-volcanic origin, are arranged in a different direction at about 141° E. (Fig. 1). The second series will be a continuation of the Fuji chain, as proved by the following evidence. Firstly, the Ogasawara chain was constructed in the Eocene epoch; the other chain belongs to a very late formation. Secondly, the second chain lies exactly upon a line drawn from Mt. Fuji over Hachijō-jima as far as Lot's Wife Rock. Thirdly, the volcanic activity of the Fuji chain is of a later date and is not yet extinguished, as shown in the active volcano of Oshima; eruptions frequently take place on the islands south of Hachijō-jima as well as on those to the north. From record we find eruptions took place on Hachijō-jima in 1487, 1518, 1522, 1605, and 1651, and on Aoga-shima in 1652, 1670, 1780, 1781, 1783, and 1785. Violent submarine eruptions occurred till 1889 on the north-west of Kitaiwō-jima, by which the water was raised several hundred feet above the sea-level. Even at the present day we find there muddy sea-water constantly disturbed. The solfataras in Iwō-jima are still constantly active. On the contrary, no volcanic activities are at present observed on the Ogasawara chain. The regions traversed by the Fuji chain are famous for hot springs, which are also seen in the islands on the southern part of the chain, namely, in Hachijō-jima at Kashidate-mura, and on Mihara-yama. In Aoga-shima and Iwō-jima hot springs are said to be everywhere found by digging into the ground. No island of the Ogasawara group has springs either hot or cold. Earthquakes are frequent on the Fuji chain, but not so in the Ogasawara islands. The Fuji chain shows many local disturbances. For instance, Iwō-jima is now being raised up so very quickly, that ground measuring a few hundred yards was upheaved above the sea-level in a few years. Very young-looking reef-corals are now seen on the plateau about 300 feet above sea-level. The islands in the Ogasawara chain have no sign of new upheaval; no coral reefs, excluding those of Miocene age, being there raised above the sea-level even at low tide.

Thus I come to the following conclusions :—

Running parallel to the Fuji chain in the southern sea is another chain, which I propose to name the "Ogasawara chain."

The latter was formed by submarine volcanoes begun in the Eocene epoch and already in repose before the Miocene, while the other chain is of much later date.

The Ogasawara chain shows andesite and variously inclined agglomerate tuff, both covered with a thick horizontal Miocene limestone layer of coral origin. Thus the several disturbances of the volcanic rocks and tuffs preceded the formation of reefs now found as elevated reefs along the ancient sea-coast.

The Fuji chain was formed either simultaneously with or very near the latter part of the formation of the Japanese Islands. The existence of the still older Ogasawara chain shows that there existed already an old weak line of the crust, parallel to and close by the Fuji chain, before the formation of the Japanese Islands.

FIG. 1.—THE NEO-VOLCANIC CHAINS OF THE JAPANESE ISLANDS (p. 298).

Chishima chain.	Yahiko chain.	Nasu chain.
Fuji chain.	Iwaki chain.	Ogasawara chain.
Kirishima chain.		
Myokō group.	Kōzu-shima.	Kita-iwō-jima.
Yatsugatake group.	Miyake-jima.	Iwō-jima.
Fuji.	Mikura-jima.	Minami-iwō-jima.
Ashitaka.	Hachijō-jima.	Tōkyō.
Hakone.	Aoga-shima.	Mukō-jima sub-group.
Atami.	Bayonnaise Rocks.	Chichi-jima sub-group.
Izu.	Smith's Island.	Haha-jima sub-group.
Ōshima.	Tori-shima	Izu-shichitō.
Toshima.	Lot's Wife Rock.	Ogasawara group.
Nii-jima.	Rosario-jima.	Sulphur Island group.

FIG. 2.—THE CHICHI-JIMA SUB-GROUP (p. 299).

Kita-shima.	Chichi-jima.	Kitafukurozawa.
Otōto-jima.	Mikazuki-yama.	Minami-fukurozawa.
Ani-jima.	Omura.	Taka-yama.
Hyotan-jima.	Futami Harbour.	Tatsumi-ura.
Nishi-jima.	Hatsune-ura.	Minami-zaki.
Hitomaru-jima.	Ogi-ura.	Minami-jima.
Higashi-jima.	Yagi-jima.	

FIG. 3.—THE HAHA-JIMA SUB-GROUP (p. 299).

Haha-jima.	Nishi-ura.	Hira-shima.
Kita-mura.	Okimura.	Mukō-jima.
Sekimon-yama.	Matsun-bōshi.	Ane-jima.
Big Bay.	Maru-shima.	Imōto-jima.
Chibusa-yama.	Futago-jima.	Mei-jima.

IV.—LIST OF THOMAS SAY'S TYPES OF MARYLAND (U.S.) TERTIARY MOLLUSCA IN THE BRITISH MUSEUM.

By R. BULLEN NEWTON, F.G.S.

TO those students interested in the palæontology of Maryland, United States, it may be welcome intelligence to know that the "John Finch Collection" of Tertiary Mollusca from that State, including some of the type-specimens figured and described by Thomas Say[1] in 1824, is in the possession of the British Museum. This fact has only recently been recognized through the examination of certain documentary evidence connected with the history of the fossil invertebrate collections contained in that institution.

During the early days of palæontological science it is quite apparent that types were not valued as they are now, for the specimens under consideration have escaped anything like proper recognition up to the present time. Without registration numbers and without labels, therefore, considerable care has had to be displayed in selecting from the extensive series of American Tertiary shells in the Museum those particular forms which agreed with the descriptions and figures of Thomas Say. The importance of these types can scarcely be over-estimated, since they form the material on which was based the first systematic description of Maryland Tertiary Mollusca. The collector, John Finch, was himself a professor of geology and an authority on the Tertiary deposits of the

[1] "An Account of some of the Fossil Shells of Maryland": Journ. Acad. Nat. Sci. Philadelphia, 1824, vol. iv, pt. 1, pp. 124–155, pls. vii–xiii.

United States, having written a paper entitled "Geological Essay on the Tertiary Formations in America" (Amer. Journ. Sci., 1824, vol. vii, pp. 31–43), besides some further works on kindred subjects. His last publication, issued in 1833, embraced his "Travels in the United States and Canada" (8vo, London), where references are made to the geology and mineralogy of those countries.

According to official documents, Mr. Finch offered his collection for purchase to the Trustees of the British Museum through Dr. Charles König, who was then the chief officer of the Natural History Department. This offer was accepted, and on the conclusion of the usual preliminaries the collection became the property of the Museum at the close of the year 1834.

Unfortunately the whole of the types have not yet been rescued; some, of course, may never be found, whilst others may come to light hereafter which have by mistake or chance been placed into wrong drawers. In any case it is a fair matter for congratulation that, after a period of 78 years since they were first described, a goodly number of these types are still preserved in excellent condition and are now available for the specialist to study.

With regard to horizons it may be mentioned that, with one exception, the species are of Miocene age, and belong to the Chesapeake formation (see Professor W. B. Clark's "Physical Features of Maryland" in the Maryland Geological Survey Report, 1897, p. 197); the exception is that of *Ostrea compressirostra*, which belongs to the Pamunkey formation, and is therefore Eocene. The nomenclature adopted in the list corresponds with the original as used by Say in 1824, without any attempt at revision.

List of Thomas Say's Types of Maryland Tertiary Mollusca described in the Journ. Acad. Nat. Sci. Phil., 1824, vol. iv, pp. 124–155, pls. vii–xiii, in the British Museum, arranged in the order of original description :—

Species.	Plate.	Figure.	Page.
Buccinum porcinum	vii	3	126
Buccinum aratum	vii	4	127
Dispotæa (gen. nov.) *grandis*	vii	6	130
Fissurella rediminula	viii	1	132
Ostrea compressirostra	viii	2	132
Pecten Jeffersonius	ix	1	133
Pecten Clintonius	ix	2	135
Pecten septenarius	ix	3	136
Plicatula marginata	ix	4	136
Area arata (left valve only)	x	1	137
Area centenaria (right valve only)	x	2	138
Area incile (left valve only)	x	3	139
Pectunculus subovatus	x	4	140
Crassatella undulata	xi	2	142
Isocardia fraterna	xi	1	143
Lucina contracta	x	8	145
Lucina anodonta	x	9	146
Cytherea convexa (right valve only)	xii	3	149
Amphidesma subovata (right valve only)	x	10	152
Panopæa reflexa	xiii	4	153
Dentalium attenuatum	viii	3	154

The types at present missing from this collection are :—

Species.	Plate.	Figure.	Page.
Turritella plebeia	vii	1	125
Natica interna	vii	2	125
Fusus 4-costatus	vii	5	127
Fusus cinereus	vii	7	129, 410
Pecten Madisonius[1]	—	—	134
Arca arata (right valve)	x	1	137
Arca centenaria (left valve)	x	2	138
Arca incile (right valve)	x	3	139
Nucula lævis	x	5	141
Nucula concentrica	x	6	141
Venericardia granulata	xii	1	142
Tellina æquistriata	x	7	145
Lucina subobliqua (described, not figured)	—	—	147
Lucina cribraria	xiii	1	147
Venus deformis	xii	2	148
Cytherea convexa (left valve)	xii	3	149
Astarte undulata	ix	5	150
Astarte vicina	ix	6	151
Amphidesma subovata (left valve) ...	x	10	152
Corbula cuneata	xiii	2	152
Corbula inæquale	xiii	3	153
Serpula granifera	viii	4	154

V.—Occurrence of Radiolaria in Gondwána Beds near Madras.

By A. K. Coomáraswámy, B.Sc., F.L.S., F.G.S.

(PLATE XVII, Figs. 1–6.)

THE Upper Gondwána (Rajmahál Series) beds near Madras are divided into two groups, the lower of which has been named from Sripermatúr, a town 25 miles west-south-west of Madras, and a well-known locality for fossil plants. The group is composed of white and pale buff-coloured shales containing plants, at least 10 feet in thickness, resting upon sandstones, grits, and micaceous sandy shales, at least 15 feet in thickness, whose base is not seen, but which probably rest on the gneiss. Silicified wood occurs in some of the gritty beds. The other fossils occur in the shales, and consist of plant and animal remains. The latter are poor, and comprise two or three indeterminable species of ammonites and several lamellibranch bivalves.

Last year, while staying at Madras I paid a short visit to Sripermatúr, accompanied by Mr. Ranga Chari, M.A., of the Madras University. I did not obtain many plant-remains, but was struck by the very porcellanic character of the shales containing them. These are thin-bedded, white to cream or pale coffee-coloured, and often have a smooth conchoidal fracture. A few specimens were collected from a wayside exposure, on the track between Sripermatúr and Vellum. In the thin slices cut from these specimens Radiolaria are to be seen, though for the most part in a very poor state of preservation. These organisms, together with tiny fragments of clastic quartz, and rarely a few carbonaceous specks, are embedded in a fine siliceous paste which remains dark between crossed nicols. Quite locally chalcedonic patches show a fibrous structure. The

[1] This species is described without a figure : the type is said to be in the Museum of the Academy of Natural Sciences, Philadelphia.

fragments of clastic quartz are rarely as large as the Radiolaria, and graduate downwards to the finest dust. Very minute bedding is clearly seen in the slides. The finer material seems to contain, or to be aggregated into, small globular masses, some of which are rather conspicuous, but very possibly not of organic origin.

Dr. Hinde has very kindly examined the slides, and says "there can be no doubt that the organisms are radiolaria." "Probably several forms are present, most of them rounded or lens-shaped discs with minute reticulate structure and without radial spines; others are oval with spines, and one form is like a sugar-loaf in section." In some cases there is a body with reticulate structure within a clear circular area; this may indicate the presence of radiolarian forms with the inner test better preserved than the outer.

There are also in the slides some groups of small rounded bodies, of inconstant dimensions, which, as stated above, are probably not of organic origin. Dr. Hinde thinks that the disc or lens-shaped forms with reticulate structure (Figs. 5, 6), which are by far the most abundant forms present, belong to the genus *Spongodiscus* in the Discoidea section. The conical perforate form (Fig. 4) probably belongs to the genus *Dictyomitra* in the Cyrtoidea division. The spined forms (Figs. 1–3) are too faintly shown for determination, but may belong to the Discoidea section.

The association of these radiolarian forms with plant-remains (the shales are known as plant-beds, though the plant-remains are not very abundant; I found no mollusca myself) is of great interest, as the shales must have been deposited in *comparatively* shallow water, a state of things also indicated by the detrital character of the other beds included in the Sripermatúr group. The shales cannot, however, have been formed very near the shore. Mr. Foote says that they "show every evidence of having been deposited in perfectly tranquil water at sufficient depths probably to be beyond the agitation of the waves. The fragmentary nature of the fronds and leaves appears to indicate that they were drifted out to sea" (Mem. Geol. Surv. India, vol. x, p. 64, 1873). The most porcellanic shales seem to contain the best preserved plants.

The Radiolaria must have been present in sufficient quantity to give a very siliceous character to the rock, yet the use of the term 'radiolarian chert' would hardly be justified. I might add that Radiolaria are to be found at the present day in shallow water, though not in such abundance as in the open ocean.

Finally, I desire to thank Dr. Hinde for his very kind assistance and advice.

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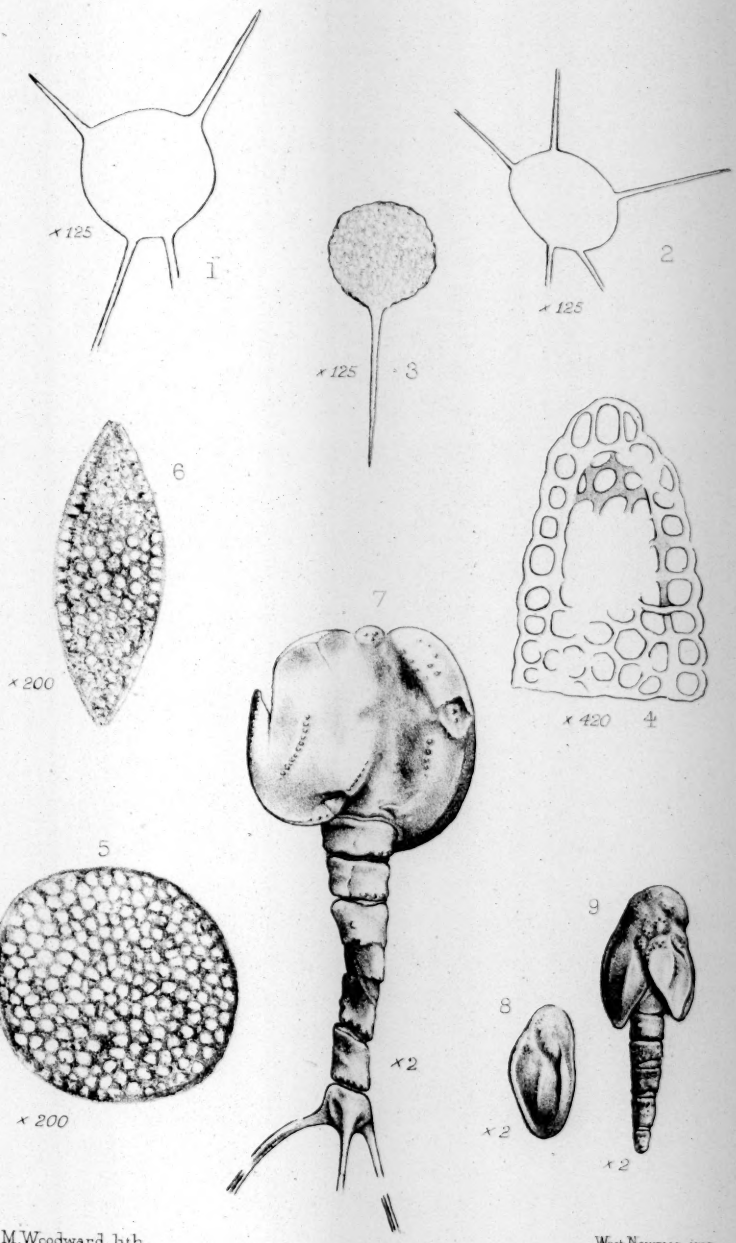
EXPLANATION OF PLATE XVII.

Radiolaria from Upper Gondwána Beds, Sripermatúr.

Figs. 1-3.—Spined forms, possibly belonging to the section Discoidea; outlines only distinguishable; × 125.

Fig. 4.—Conical reticulate form probably referable to the genus *Dictyomitra*, × 420.

Figs. 5, 6.—Lenticular reticulate form perhaps belonging to the genus *Spongodiscus*, × 200.



G. M. Woodward, lith. West, Newman, imp.

Figs. 1–6. Radiolaria, *from Madras.*

Figs. 7–9. Echinocaris, *from Devonshire.*

VI. — *Echinocaris Whidbornei* (Jones & Woodward) and *Echinocaris Sloliensis*, n.sp.

By Miss E. M. Partridge.

(PLATE XVII, Figs. 7–9.)

DURING the last year the Marwood Beds of Sloley Quarry, near Barnstaple, have yielded some additional specimens of *Echinocaris*, which have afforded material for the present note. The specimens have all been found in the fine micaceous shaly beds, six to eight feet thick, on the north side of the quarry, below the massive sandstones, and above the shallow-water bed containing plant-remains, rain-prints, worm-tracks, etc. The same shaly beds contain *Lingula squamiformis* in abundance; other bivalves are less frequent. They have now yielded as many as twelve specimens of *Echinocaris*.

Echinocaris Whidbornei (Jones & Woodward).

One of the recently discovered specimens (Fig. 7) is more complete than any hitherto found. The *carapace* is much crushed. The six *abdominal segments* are well preserved; the abdomen tapers posteriorly. The segments increase in length towards the posterior segment, the anterior somites being twice as long as wide, the posterior somewhat less wide than long. The posterior margins of the segments are furnished with nodes or short spines, those of the two anterior segments being small and few in number. The four posterior segments have also one or two short nodes or spines on the dorsal or lateral surface. *Telson* smooth, slightly smaller than the last abdominal segment, triangular in outline, produced into a long slender spine quite twice as long as the posterior abdominal segment. Ventral surface of this spine with a central furrow, shown on the mould as a ridge, where a portion of the spine has been broken away. Attached below the telson are two other spines, which are slightly longer than the spiniform extension of the telson. These spines also have a central furrow along the ventral surface.

Measurements: Abdomen, 18 mm. long; segments, commencing with the anterior, respectively about 2, 2·2, 2·7, 3 (?), 3, 4 mm. in length; telson, 2 mm. long by 2·5 wide; telson and spine, when complete, together 10 mm.

Echinocaris Sloliensis, n.sp.

The description is based on two specimens (Figs. 8, 9), for one of which I am indebted to Mr. F. J. Partridge, who discovered it. The other was found by Mr. A. K. Coomáraswámy. Neither specimen is complete, nor are they very well preserved. *Carapace* convex, elongate-ovate in outline, the valves about twice as long as broad, or more. Margins thickened, carinated, but wider and flattened at the posterior ends of the valves, which ends are rather widely separated. Cephalic region not well preserved in

either specimen; the cephalic swellings similar to those of *E. socialis* (Beecher). The thoracic portion of the valve possesses two ovate tubercles, one (the smaller) parallel with the outer margin and situated in the upper outer corner of the thoracic portion of the valve; the other is situated transversely, and found in the upper dorsal portion near the hinge. Along the outer margin of the first tubercle runs, parallel with the margin and towards the posterior angle of the valve, a sharp, almost smooth carina; at its upper end it bends outward to the ventral margin of the valve. From the other tubercle runs a second, nodose ridge, almost coinciding with the dorsal line, and continued along the margin of the valve. In the centre of the area enclosed by these two ridges is a longitudinal row of minute nodes, ornamenting a third carina. The other elevated portions of the valves possess also minute irregular tubercles, but the outer carina is almost or quite free from these. *Abdomen* composed of six visible segments (the telson being absent in our specimens), the whole tapering, the posterior segments a little longer than the anterior. The posterior margins of each segment are ornamented with a number of small nodes, the anterior segments possessing fewest of these. A few tubercles are also found on the surface of the segments between the posterior and anterior margins.

Measurements: Length of valves, 9–10 mm.; greatest width of a single valve, 4·7 mm.; abdomen, 11 mm. long.

This species much resembles *E. socialis* (Beecher), but the carapace is much longer in proportion to its width. The outer carina also is almost or quite smooth, and bends outward to the ventral margin of the valve instead of fusing with the tubercle as in *E. socialis*. The middle carina is also more prominent than in *E. socialis*.

I am much indebted to Dr. Henry Woodward for kind assistance and advice in the preparation of this note.

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EXPLANATION OF PLATE XVII.

Echinocaris from the Marwood Beds, Sloley Quarry, near Barnstaple.

Fig. 7.—*Echinocaris Whidbornei* (Jones & Woodward). Partridge Collection. × 2.

Fig. 8.—*Echinocaris Sloliensis*, n.sp., right valve of carapace. Coomáraswámy Collection. × 2.

Fig. 9.—*Echinocaris Sloliensis*, n.sp., another specimen, more complete. Partridge Collection. × 2.

VII.—Monzoni and Upper Fassa.

By M. M. Ogilvie Gordon, D.Sc.

THE following pages present some results obtained by me from the geological survey of the Fassa district in the Dolomites comprising the Bufaure and Monzoni mountain groups, where the porphyritic and monzonitic rocks are widely exposed. In selecting this district I had two objects in view—(1) to study in detail the tectonic relations between the igneous and stratified rocks; (2) to test the results which I had previously obtained from my survey of Sella Massive, etc.

The Tertiary Age of Monzoni.

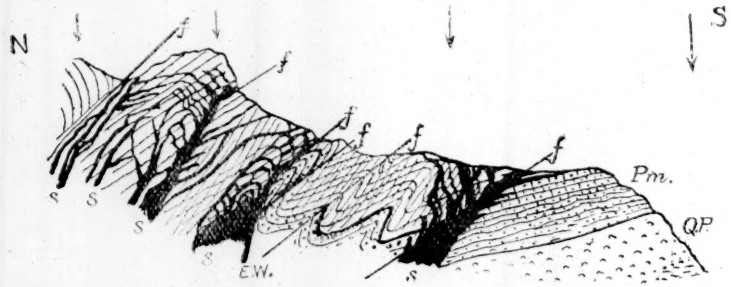
The Campagnazza Meadowland stretches east of Monzoni as undulating slopes descending southward from the Costabella range of limestone to the Pellegrino Valley. The meadowland is composed of Permian and Werfen strata, and I discovered in it a number of intrusive sills of porphyrite associated with two faults. The more northerly of the faults runs east-west at the southern base of the Costabella range, and it continues westward as the northern fault-limit of the Allochet ridge and Monzoni. This fault is steeply inclined to the north, and the differential movements have effected the relative downthrow of the Costabella fault-block on the north. The other fault follows a curved strike, its course being E.S.E.–W.N.W. in the Campagnazza, but curving to E.N.E.–W.S.W., where it is continued as the southern fault-limit of the Allochet ridge and the monzonite rocks of Monzoni. The curvature is convex towards the north, and the fault-plane is inclined northward. In the Campagnazza there is north of the fault a crumpled sheared slice of Werfen strata; but this block is represented at Monzoni by the intruded igneous rocks. The tectonic relation of the monzonite intrusion is therefore that of a fault-sill, representing in the strike the Campagnazza crust-slice between the two faults, and injected at an angle of strike-curvature.

The fault-block south of the curved fault may be conveniently termed the Pellegrino fault-block. It comprises quartz porphyry, Permian strata, and fault-fragments of Werfen strata, and has been driven southward, representing one of a series of overthrust slices which occur south of the Pellegrino Valley (Fig. 1).[1] Still farther south the Cima d'Asta overthrusts are present, and as there are occurrences of Jurassic and Cretaceous strata in the shear-zones of the overthrust faults, it is clear that the slicing took place in connection with Tertiary movements in the Alps. The Campagnazza fault-curves were certainly not earlier than the overthrusts; thus, my geological mapping, which proves the replacement of the Campagnazza sheared slice by the monzonite intrusion, proves at the same time that the intrusion was of Tertiary age. I find further that I can offer an interpretation of the sequence of injections

[1] I have made no personal examination of the district south of the Pellegrino Valley.

in the Monzoni mountain based upon the details of strike-cleavage in the Campagnazza Meadowland and Monzoni.

The Costabella downslip slice strikes N. 75°–80° W., the Campagnazza shear-slice strikes N. 65° E., the Pellegrino thrust-slice strikes N. 65°–80° W. These facts indicate that the proximal crust-slices have adjusted themselves in the Campagnazza along different strikes, the one being the differential correlative of the other. But at Allochet the strike both of the Costabella and Campagnazza crust-slices curves to the E.N.E.–W.S.W. direction, and the monzonite rocks of Monzoni have this as their fundamental strike, the dip-cleavages being towards the north-west at an angle of ca. 50°, and towards the south-east at an angle of ca. 40°. The E.N.E. and W.N.W. strikes may both be suitably termed 'Asta' strikes, from the famous Cima d'Asta Massive in the Dolomites, where Professor Suess first determined overthrust movement towards the S.S.E.



Transverse section through the Costabella range (Middle Triassic limestone); the Campagnazza Meadowland (Lower Triassic mixed deposits and fault-fragments of Permian strata); the slopes of Pellegrino Valley (Permian strata (*Pm.*) and Quartz Porphyry (*Q.P.*)); *f f*, 'Asta' faults; *E.W.*, old east-west fault; *s s*, porphyrite sill and dyke system ascending faults, cleavage-planes, and bedding-planes.

In my previous papers I have demonstrated that these correlative strikes developed in consequence of the superposition of the Peri-Adriatic movements upon the regional East Alpine movement, and this explanation is fully borne out in the Campagnazza. The east-west fault north of Monzoni and the Campagnazza is, according to my researches, an old synclinal fault between two fundamental East Alpine anticlines, that of the original Pellegrino anticline on the south of the fault, and on the north of it the anticline which I shall term the Contrin anticline, from its favourable exposure on the Contrin Alpe north of the Costabella range.

The north fault-limit of Monzoni with east-west direction has in previous literature gone by the name of the 'eruptive fissure,' and probably the direction of this fault gave the erroneous impression that the monzonite had a parallel strike. But the monzonite rock both here and in the Predazzo area, a little to the south-west of Monzoni, strikes E.N.E.–W.S.W., and as will appear from what follows, the original intrusion of monzonitic magma was a continuous

'Asta' fault-sill—the western or Predazzo portion having been *subsequently* displaced southward, and downthrown relatively to the Monzoni portion. Again, the 'eruptive fissure' has been described as "probably" continuing through a porphyrite fault-dyke east of Lago di Selle and passing E.N.E. through the Costabella range. This is, however, not the case. The east-west fault holds its own direction, passing due east into the Campagnazza. I regard it as one of the leading Alpine faults in this district, comparable with the Gröden and Buchenstein faults which I have described in my former papers. Its age *may* be far greater than the injection of the monzonite, seeing that the injection was synchronous with the superposed 'Asta' movement. Moreover, the term 'eruptive' was applied under the conception that Monzoni was a volcanic centre in Triassic time, the monzonite being the deep-seated facies of Triassic surface flows of porphyritic lava and tuff. This I hold to be a mistaken conception, as I have carefully examined all the supposed surface flows of porphyrite in the vicinity of Monzoni and in Upper Fassa, and have found them to be intrusive sills and dykes, injected subsequently to the main intrusion of monzonite, at that epoch in fact when the monzonite fault-sill was cross-sliced, and its western portion laterally displaced as far as Predazzo. According to my mapping of this district there are no igneous *contemporaneous* rocks later than the quartz porphyry except the tuffs in the Wengen-Cassian beds.

Having now pointed out how some of the older misconceptions regarding Monzoni may have arisen, I shall proceed to indicate briefly a few of the leading observations I have made throughout the district.

The Miocene Age of Porphyrite Sills.

Fig. 1 is a generalized transverse section through the Campagnazza Meadowland and the Costabella range. It shows how the two crust-slices, the Campagnazza and the Costabella slices, are themselves cut by subordinate fractures. These are 'Asta' fractures, striking either E.N.E. or W.N.W.; the inclination of all shear-planes is northward, but the angle of inclination varies very considerably. The chief tectonic complications occur in the immediate proximity of the older east-west fault. In the *eastern* or Fuchiade part of the Campagnazza, a small segment of older strata is at this fracture overthrust above Upper Werfen strata. In the *middle* part of the Campagnazza, several porphyrite fault-sills ascend at this shear-zone. The *western* or Allochet portion near Monzoni, like the middle area, shows several shear-planes and porphyrite fault-sills, but the strata dip more steeply. The porphyrite sills run continuously from the 'Asta' faults into virgating cross-faults directed N.N.W.–S.S.E. and N.N.E.–S.S.W. Two virgating groups of faults and fault-dykes divide the Campagnazza into the three segments which I have indicated—the Allochet segment on the west, the middle or main cross-segment, and the Fuchiade segment on the east. The middle segment is an upthrow relatively to the segments

east and west of it; the cross-fault limiting it against the Allochet ridge is directed N.N.W.–S.S.E., but the cross-fault limiting it against the Fuchiade segment on the east is directed N.N.E.–S.S.W. Hence the leading strike-curve of the Campagnazza is convex to the north.

The diagonal fault-dykes continue their course northward and cut the Costabella range into similar cross-slices. In the Costabella range the fault-dykes are again continuous with sills which follow the strike, penetrating the strata at various horizons. Two leading sills are fault-sills,—the lower is injected at the horizon of Mendola limestone, the higher is included in a complex shear-zone of Cassian and Schlern limestone horizons. The latter has previously been regarded as the direct continuation of the east-west fault, but it is only one of several branches from the east-west fault, diverging E.N.E. from the Lago di Selle plateau.

The whole rock succession in the Campagnazza and Costabella has undergone vertical cross-cleavage according to a north-east and south-west (N. 40° E.) strike, and inclined cross-cleavage along a N.W.–S.E. direction with the dip-cleavage planes inclined south-east at an average angle of 35°–40°. The intrusions of porphyrite ascend chiefly in the planes of strike-cleavage, and the sills occupy irrespectively the north-dipping bedding-planes and the inclined cleavage-planes with south-east dip. I have incontestible proofs (1) that injections run continuously into the Asta planes and the planes of cross-cleavage; (2) that the cross-cleavage strike and dip system has disjointed and deformed the Asta strike and dip system; and I therefore conclude that the leading porphyrite sills and dykes in this area were coeval with the superposition of the cross-cleavage system. In previous papers I have called the cross-cleavage system the 'Judicarian' system, and referred it to the Miocene geological epoch, treating it as a more advanced phase in the protracted history of superposed movements than that which gave origin to the E.N.E. and W.N.W. strikes. The 'Judicarian' and 'Asta' systems of strike have orthogonal correlation with one another, the N.N.E. 'Judicarian' strike being rectangular to the W.N.W. 'Asta' strike, and the N.N.W. 'Judicarian' strike being rectangular to the E.N.E. 'Asta' strike. Thus cross-cleavage was superinduced upon the 'Asta' strike-system, but the differences in the detailed stratigraphy of the cross-segments in the Campagnazza show that both systems were acting simultaneously, the orthogonal stresses being associated with the superposition of the N.N.E.–S.S.W. or 'Judicarian' strike upon the fundamental east-west 'Alpine' strike.

The Cross-Cleavage of Monzoni.

The 'Asta' injection of monzonite apparently engulfed the stratified rocks of the Permian and Werfen horizons, and as it consolidated did so in conformity with the actual strike and dip of the bedding-planes above, around, and amidst them. The rock-magma, owing to the action of the local pressure-strains, consolidated as a series of gneissose zones, and these original segregation zones have the

E.N.E. strike and northward dip of the whole mass. In succession from south to north the zones are: (*a*) the lowest zone, a light coarse-grained monzonite specially rich in mica; (*b*) a finer-grained differentiation of the micaceous type of monzonite: (*c*) a coarse-grained, pyroxenic, or gabbro-like monzonite; (*d*) a finer-grained dark type, highly augitic; this uppermost zone sends short apophyses into the limestone of the peripheral zone.

Differential movements subsequent to the 'Asta' injection of monzonite have concentrated themselves at the zone between the finer-grained micaceous type and the coarse gabbro-like monzonite. The dip-joints curve steeply northward at this horizon, and the augitic segregation zones have been downthrown to the north and west and sliced by several shear-planes both in strike and cross directions. *The chief fault-zone runs entirely through the Monzoni mountain*, following a curved strike, which, like the Judicarian-Asta fault-system round Allochet and Campagnazza, is convex to the north. The fault-zone through Monzoni is parallel with the peripheral fault-system, limiting Monzoni on the west, north, and east. In the fault-zone the monzonite rock is sheared and slickensided in the very highest degree, having been converted into a monzonite fault-schist, or in some places into a coarser fault-breccia. Moreover, *the fault-zone is the seat of later injections*, in contact with which the earlier gneissose bands of monzonite have endured extreme contact alteration. The later injections have two very important tectonic features in common with the porphyrite sill and dyke system of the Campagnazza. They extend continuously in the strike fault-curve through Monzoni, and in numerous cross-faults (N.N.W., N.S., and N.N.E.) which cut Monzoni into a series of cross-segments comparable with those of the Campagnazza. This feature in itself gives a safe indication that the later injections in Monzoni were, like the porphyrite sills in the Campagnazza, associated with the 'Judicarian' movement. But there is still stronger evidence. The whole of Monzoni has been cross-cleaved, the strike-cleavage being north-east to south-west, and the slabs of dip-cleavage being inclined to the south-east. The cross-cleavage planes of Monzoni are in fact a repetition of those displayed in the stratified rocks of the Campagnazza, and the differential correlative planes are similarly developed. The later injections in Monzoni ascend pre-eminently the vertical cross-cleavage planes or the inclined planes dipping south-east. Thus it may be safely concluded that the later irruptions in Monzoni took place in the Miocene epoch when the Asta-Judicarian movements had reached their most intense phase in the Alps.

The series of later injections includes a much greater mineralogical variety of igneous types than the earlier intrusion. The first injections of the later series include somewhat abnormal augitic and hornblendic types of monzonite and a still more basic olivine-gabbro type, coarsely crystalline for the most part, but passing into basaltic facies. This rock is readily recognized in the leading fault-zone by its characteristic ferruginous and serpentinous decomposition products. It also runs northward as cross-dykes in the rugged

spurs that descend to the Monzoni Alpe. Certain peripheral dykes of very basic types of monzonite are also of this period.

The next set of injections show marked differentiation into granitic and augitic varieties. Usually the injections are found in group form, the more acid and more basic types occurring together or within a few yards of one another. Dyke-pairs of granite and porphyrite or of monzonite aplite and hornblendic monzonite are very common, and there are fault-dykes of aplite, pegmatite, or highly felspathic monzonite. Seams of orthoclastic rock are freely injected both in strike and cross directions. Those groups, pairs, or seams of smaller dykes occur across the olivine-gabbro and normal monzonite rocks in Monzoni, and also sporadically at the peripheral shear and contact-zone, where they are very often associated with a fine-grained basic porphyrite that weathers greenish, and answers in its thinner threads to the description of the igneous rock which has passed in the literature under the name of 'pietra verde.'

The last injections include liebenerite porphyry, plagioclastic porphyrite, and some ultrabasic limburgite types. Their occurrence in the field is in north-south direction or very few degrees east or west of this direction. They cross all other dykes; several excellent exposures that I found prove them to be the youngest type of injected rock in Monzoni. They mark certain 'focal areas' within the mountain where strike and cross faults intersect. At these areas local inthrows have occurred in relation to a cross-movement from east to west, whereby cross-slices of Monzoni were overthrust westward, and behind each thrust-slice there was a zone of downslip and inthrow.

The western thrust-slices present an arrangement of gneissose bands following strike-curves convex to the west. This strike-curve is orthogonal to the strike-curve convex to the south, which is characteristic of the front portions of the Pellegrino and other thrust-masses overthrust to the S.S.E. The focal areas around which these transverse or 'Judicarian' strike-curves are arranged occur within Monzoni, but the focal area corresponding to the general strike-curve of the monzonite rocks is immediately north of Monzoni, at an area in Monzoni Alpe where inthrow has taken place, and where the N.N.E., N.S., and N.N.W. cross-faults that radiate through Monzoni converge.

I regard the olivine-gabbro and contemporary basic types of monzonite in Monzoni as the deeper-seated facies of the massive porphyrite sills that spread through the Triassic horizons in the neighbouring districts; whereas the granites, aplites, and the more segregated types of porphyrite and monzonite in Monzoni were coeval with certain fine-grained basic injections into the porphyrite sills of the vicinity.

The occasional ultrabasic dykes in north-south cleavage-planes were still later. In Monzoni, in the neighbourhood of the chief shear-zone, the rocks have been rippled along an east-west strike; in the Allochet ridge east of Monzoni there is rippling in this direction, and cross-rippling due north and south. The wave-length

of these ripples is quite short, but as the whole area shows north-south cleavage, I consider them confirmatory evidence that the East-Alpine pressure-system acted intermittently or synchronously with the Judicarian-Asta pressures, and that as these pressures temporarily waned after the epoch of crust-slicing and igneous intrusions, the effects of the East-Alpine movement became more pronounced. Whether this explanation be correct or not, the stratigraphy shows that horizontal compression acted along east-west and north-south directions after the epoch of the most intense Judicarian and Asta movements.

The Contrin and Buchenstein Anticlines.

The Permian and Werfen strata are widely exposed on the Contrin Alpe, and the essential features in the stratigraphy of the anticline are more easily obtained than in the Pocol and Monzoni Alpes farther west. According to my mapping, the original north limit of the Contrin anticline was an east-west fault through the present Bufaure Massive from Mazzin in Fassa Valley to Penia at the confluence of the Upper Avisio and the Contrin streams, the fault continuing eastward through the Upper Avisio Valley, westward through the Udai Valley. The original south limit of the Contrin anticline was the east-west fault north of the Campagnazza and Monzoni area. The present distance between these two faults is, as the crow flies, about $6\frac{3}{4}$ kilometres.

The Contrin anticline is succeeded on the north by another east-west anticline, that of Upper Fassa. It is the continuation of an anticline to which I previously gave the name of the Buchenstein anticline (Q.J.G.S., 1899, p. 583). In Upper Fassa the Triassic strata belonging to this anticline are exposed in the northern half of Bufaure, in the Upper Fassa slopes, in Rodella Mountain, in the slopes of Mount Donna, in the Sella Pass, and in the southern half of the Sella and Langkofl mountain-massives. The old east-west fault which forms the original limit of the Contrin anticline on the north, is the *southern* fault-limit of the Buchenstein and Upper Fassa anticline. The *northern* fault-limit of the Buchenstein anticline, as demonstrated by me in former papers, passes through the Langkofl and Sella limestone-massives, through Stuores Alpe and the north of Sett Sass, being at the same time the southern fault-limit of the Gröden anticline. The distance between the limiting-faults of this anticline in Upper Fassa is the same as the width of the Contrin anticline, viz. $6\frac{3}{4}$ kilometres. Both anticlines have undergone cross-deformation in virtue of the superposed Asta-Judicarian movements. In several cases that I have measured, the width of the complete wave-form of the Judicarian cross-movement is in this locality $5\frac{1}{2}$ kilometres.

The Asta-Judicarian movements have produced a series of over-thrust and downslip crust-slices following strike-curves, and cross-faulted as in the case of Monzoni. The porphyritic sheets have been injected in the downslip shear-zones behind the thrust-masses of Werfen and limestone strata, and in 'Judicarian' cross-faults;

they have locally broken through the thrust-masses as fault-sills and dykes, brecciating and altering the strata, the igneous and brecciose material thus replacing the strata along the strike of the thrust-masses. Accordingly I dissent from the opinion advanced by Mojsisovics and repeated in slightly different form by Salomon, that the igneous rocks of Bufaure, Belvedere, etc., constituted a volcanic Triassic facies of the Marmolata limestone. The massive sheets of porphyrite at Bufaure, etc., are wholly intrusive and run into radial and strike fractures associated with the Asta-Judicarian movements. The stratigraphy of the district will be fully set forth in the geological map and sections that are to accompany my complete paper.

Block-Porphyrite.

Some of the most puzzling problems concerning the mineralogy of the district are associated with the block-porphyrite ('Block-Porphyr' of Mojsisovics), or, as it has been frequently termed, the conglomerate or 'agglomerate' structure of the igneous rocks. The explanations offered by all who have surveyed in this district except myself have been based upon the assumption that the Bufaure and neighbouring sheets of porphyrite were contemporaneous Triassic lavas. During my own field-work I have had to make a close investigation of various sills of block-porphyrite, and find that the conglomeratic appearance is due to various causes. While in many cases the block-structure is simply a result of original segregation in concretionary lumps or lenticular patches and bands, there are others where the structure is superinduced. I found it necessary to determine the joint-cleavage systems in the porphyrite very carefully, as the later, more basic injections have frequently been injected along the joint-planes, and so encircle isolated masses of an earlier sill, just as the sill-magma itself enwrapt or infiltrated particular masses of strata when it was injected. I classify the different types of block-structure as follows :—

(a) *Original agglomeratic structure* dependent upon various forms of segregation products;

(b) *Joint-block structure* due to decomposition and weathering of the porphyrite along intersecting curved joints;

(c) *Superinduced brecciose structure* where a sill has after consolidation been subjected to differential shearing;

(d) *Combination-sill structure*, where intermittent injections have passed into the same fault-zone, and the later injections have broken up the older.

The Sella Pass.

The north wing of the Buchenstein anticline occupies a crust-zone in which old eruptive fissures of Triassic age occurred. I have previously determined the Buchenstein-Mahlknecht fault-zone extending east and west through this area, and have pointed out that the tufaceous as contrasted with the calcareous facies developed in the proximity of, and north of, this Triassic fracture-zone during the

Wengen-Cassian epoch, and that the northern area was especially subject to local variability during the Upper Cassian and Raibl periods (ant. Q.J.G.S. 1893, Geol. Mag. 1894 and 1900, Verhandlungen 1900). In 1900 I prepared a transverse section through Sella Pass on the north of the fracture-zone, according to which the stratigraphical succession is as follows:—(1) *Wengen* tuffs and shales with the typical plants and bivalves; (2) *Cassian* limestones, marls, tufaceous shales and grits, containing the typical Stuores-Cassian fauna together with *Pachycardia rugosa* and several other species found at Seiser Alpe, but not, so far as yet known, at the Stuores locality near St. Cassian; (3) Upper Cassian limestones and tufaceous marls and breccias; the 'Cipit-Kalk' or reef-limestone lenticles are imbedded in tufaceous rocks containing a transitional Cassian-Raibl fauna, and passing conformably under the Schlern-dolomite rocks of the adjacent mountain-massives. At Sella Pass numerous specimens of *Pachycardia rugosa* occur at both the Cassian zones; on the other hand, certain forms such as *Trigonodus Rablensis* and certain species of *Avicula* make their first appearance in the Upper Cassian zones. The rich fauna found in the 'Pachycardia tuffs' of the Seiser Alpe (v. Zittel, Zeitschrift, 1899) is very well represented at Sella Pass. And comparing my Sella Pass section with my former sections in Enneberg and Ampezzo, the 'Pachycardia tuffs' are demonstrated to be *the time-equivalent of the whole St. Cassian series.*

It has previously been supposed that the Wengen-Cassian series were absent in Fassa, but I have found that although thinly developed, the Wengen and Stuores-Cassian zones are present at the base of the Vallaccia limestone massive between Fassa Valley and Monzoni, and at the base of the Punta di Costabella.

REVIEWS.

Om de Senglaciale og Postglaciale Nivåforandringer i Kristianiafeltet (Molluskfaunan). Af W. C. Brögger, med Bidrag af E. B. Münster, P. Öyen, o. pl. Med 19 plancher og 69 figurer i Texten. Norges geologiske undersögelse, No. 31. (Kristiania: H. Aschehoug & Co., 1900 og 1901.)

On the Late Glacial and Post-Glacial Changes of Level in the Christiania Region. By W. C. Brögger, with contributions by E. B. Münster, P. Öyen, and others. Norwegian Geological Survey, No. 31. 8vo; pp. 731, 19 plates, and 69 figures in the text.

THE changes which Norway has passed through in the concluding portions of the Glacial period and subsequently to the present time, have not been so systematically and thoroughly investigated as those in the eastern portion of the Scandinavian peninsula, and though various branches of the subject have been described during the last fifty years the Norwegian geologists have not, as a rule, specially concentrated their researches on this part of the geological

history of their country. This circumstance moved Professor Brögger, although, in his own estimation, no specialist in the field of glacial geology, to trace out in detail the important series of changes which accompanied and followed the retreat of the last great ice-sheet which covered Southern Norway. Nowhere are the records of these changes better preserved and more clearly shown than in the districts bordering the Christiania fjord, a region which the author has already made classical by his well-known description of its Palæozoic geology and fossils.

Although the title of the work refers to the changes of level which the country has undergone in the period under consideration, the evidence of these, to a great extent, is furnished by the characters of the molluscan fauna in the various deposits, and the work gives mainly the results of a detailed study of the changes which have taken place in this fauna by the introduction of certain species and the disappearance of others. Not only changes of level but modifications of the climate are also indicated by the various phases of the molluscan life which flourished in the Christiania fjord after the retreat of the ice-sheet.

The author treats the subject under three main divisions or periods. The first of these—the period of subsidence—begins at a time when the front of the glacier extended across and on both sides of the southern portion of the Christiania fjord, and in front of it huge terminal moraines were being formed beneath the sea-level, while outside of these the Yoldia-clays were laid down. The level of the land at this time was not much lower than at present, but a movement of depression had set in which continued until the land had sunk to the extent of about 240 metres (787 feet), and the sea margins reached to the southern end of Lake Mjösen and the other lakes of Central Norway. During this sinking interval the land-ice was gradually melting back northwards, leaving behind, at successive stages in its retreat, huge ramparts of terminal moraines indicating prolonged pauses in its recession. Over the areas vacated by the ice, beds of shelly clays were deposited; the shells for the most part are of Arctic species, but in the later stages of the depression there was an admixture of boreal forms.

The second period was ushered in by a movement of elevation, and its various stages are shown by the abundance of shelly sands and gravels at different levels above the sea, and to a subordinate extent by clay-beds as well.

The third, or post-Glacial period, commences about the middle of the elevatory stage and continues to the present. It is characterized mainly by shallow-water sands and gravels, with numerous shells and clay-beds as well. The mollusca are now for the most part boreal, and southern forms and the principal Arctic species have disappeared.

I. *The Period of Subsidence.*

Returning now to the late Glacial period of subsidence, the author states that the terminal moraines—or *ras*, as they are designated—

consist of enormous masses of stratified sand and gravel of rolled pebbles, with patches of clay, which have been brought down by the streams produced by the melting ice and deposited beneath the sea-level immediately in front of the glacier. In structure they may be compared to *åsar*, but their position is that of terminal moraines. The outermost *ra* crossing the Christiania fjord has been assumed to represent the furthest extension of the land-ice during the last glaciation of the country, but this is incorrect, for the rock surfaces beyond the ra are glacially striated in the same way as those behind it, and there is no doubt that the ice of the last glaciation reached outwards, beyond the present shore limits of the country.

Outside the terminal ra, that is, between the moraine and the coastline, but never within the morainic barrier, there is a widely spread deposit of clay, known as the Yoldia-clay, which in places rests directly on the striated surfaces of the ancient rocks and in places on the outer slopes of the ra, from below the present sea-level to 40–45 metres above it. The clay consists of a fine mud, often with stones and boulders of porphyry, syenite, and granite, originating from the central and northern portions of the Christiania region; many are typically striated. Molluscan shells of large size, indicating favourable conditions of existence, are abundant in the clay. Twenty-six species have been determined; the commoner and most characteristic forms are *Portlandia (Yoldia) arctica*, Gray, *Macoma calcaria*, Chem., *Saxicava arctica*, Linn., *Leda pernula*, Müll., and *Nucula tenuis*, Mont. The first of these occurs nearly everywhere; both valves are usually found united, and the epidermis and ligament are preserved. In places the clay contains numerous foraminifera; one species, *Polystomella arctica*, Park. & Jones, is a typically Arctic form. The mollusca of the Yoldia-clay are now all found living in high Arctic regions at depths of 10–30 metres; most of them are present in the Kara Sea, and it may reasonably be assumed that these fossils lived under similar conditions of depth and temperature as their recent representatives. The Yoldia-clay with its characteristic fauna can be traced on the sea-bottom round the coast of South Norway to depths of over 70 fathoms, which shows that during the earlier deposition of the clay the land must have been at a higher level than at present. The shells appeared to have lived contemporaneously with the formation of the outer ra, and the land appears to have sunk during this period from about 50 metres above to 70–75 m. below the present level.

The question of the elevation of the land in Norway before the ra period, during the time of the great glaciation, is discussed by the author in connection with the occurrence of sub-fossil shells, of species which, living, are found at depths of only a couple of fathoms, in the sea between Norway, Spitzbergen, and Greenland, where they occur at depths of 20–500 fathoms. Further, dead shells of shallow-water forms like *Portlandia arctica* have been dredged up from depths of 656–1333 fathoms off Spitzbergen, where they are associated with numerous otoliths of fishes. Dr. Nansen agrees with the author that these dead shells are distributed over too

wide areas to be accounted for by ice-transport from the shallow-water localities round the coast, and on the supposition that they are now in the spots where they lived, it would be needful to postulate a former elevation of the sea-bottom to the extent of 800–1400 fathoms. Brögger considers that during the great glaciation the land may have been elevated perhaps to 2,600 metres above its present level, and this would furnish an explanation of the formation of the deep fjords, and of the movement of the land-ice from the Scandinavian highlands to the central European plain during the great glaciation.

The banks of dead littoral shells forming a continental platform along the west coast of Norway, at depths of 100–300 metres, are compared with the sunken shell banks of Rockall and those off the Faroe Islands, and they are considered by the author to point to a widespread elevation of the sea-bottom amounting to 100–300 metres in the last interglacial period, which may have continued during the last glaciation of Norway.

In the lower part of the valley of the Glommen, near Frederikstad, the lower Yoldia-clay is overlaid by another clay not more than 1–2 metres in thickness, containing nearly the same fauna as the lower bed, but the forms are smaller, and some new species appear, for example *Yoldia hyperborea*, Loven, which lives at greater depths than *P.* (*Yoldia*) *arctica*. These facts show that the upper Yoldia-clay was formed at greater depths than the lower, and that the sinking of the land was continuous.

The upper Yoldia-clay gradually passes upwards into another deposit, only a few metres in thickness, in which most of the species are new, whilst *Portlandia arctica*, the characteristic shell of the Yoldia-clays, has quite disappeared. Amongst the principal forms are *Arca glacialis*, Gray, and *Portlandia lenticula*, Fabr., and from the first of these the beds are named Arca-clays. They contain about twenty species of mollusca, all high Arctic forms, which now live at considerable depths in the Polar Sea, and it is probable the beds were laid down at depths of 80–100 metres. Like the Yoldia-clays, the lower Arca-clays are only found outside the ra, and as some of them are now 25–40 metres above the sea-level, it follows that the land, at the closing period of the outer ra, was 100–125 metres lower than at present.

After the deposition of the lower Arca-clays on the areas beyond the outer ra, a somewhat rapid change in the rate of melting of the glacier took place, which resulted in the retreat of the ice northwards up the Christiania fjord for a distance of 20–25 kilometres, where another pause was made which resulted in the formation of the Svelvik terminal moraine, or inner ra. In structure this resembles the outer ra: it was laid down beneath the sea; its present height is 150–190 metres above the sea-level. It has a length of about 2 kilom., and the breadth of its base is $1\frac{1}{2}$ kilom. Two-thirds of its materials consist of sand; the remainder are pebbly gravels of granite, hornblende schist, and quartzite, with a few angular striated boulders.

The extensive areas between the outer and the inner ra are covered by thick deposits of clay which rest directly on the striated surfaces of the older rocks. Only a scanty fauna of about a dozen species, most of them of a high Arctic character and similar to those in the lower Arca-clays, are known from these beds, which are termed the middle Arca-clays. The principal forms are *Arca glacialis*, distinctly smaller than those in the lower beds, and *Portlandia lenticula*. These middle Arca-clays are now at levels of 150 metres above the sea; they indicate a further sinking of the land during the withdrawal of the ice from the outer to the inner ra.

From the inner ra at Svelvik the glacier melted back northwards to the valleys of Drammen, Lier, and Christiania, where the third stage in its retreat is marked by terminal moraines, similar to those lower down, most of which served to dam up lake-basins behind them. In the districts vacated by this stage of the ice retreat, Brögger has recognized a clay deposit of deep-water origin, the younger or upper Arca-clay, in the lower parts of the valley, up to about 120–130 metres above sea-level, containing thirty-seven species of mollusca, and somewhat higher, at levels up to 175 m., a clay of a somewhat shallower character, named the younger Portlandia-clay. The fauna of the younger Arca-clay is not, like that of the older Yoldia-clays, of a purely Arctic character, for only about half the species in it are now living in the Kara Sea; it contains an admixture of boreal species, and it corresponds with that now existing at depths of 100–200 m. off the north coast of Norway.

The further withdrawal of the ice northwards is marked, as hitherto, by moraines at intervals where pauses have taken place; the fourth of these occurs behind the clay terrace at Lilleströmmen, and a fifth at the south ends of the large lakes of Central Norway—Mjösen, Hurdalsvand, Randsfjord, etc. At this fifth or epiglacial station, as it is designated, enormous masses of clay, and upon these to the north, sands and gravels, are spread over the terraces of Romerike and part of Ringerike. These gravels appear to have been all laid down beneath the sea; they are now about 225 metres above sea-level. But few mollusca are found in the clays between the third and epiglacial moraines; the principal species are *Portlandia lenticula* and *Astarte compressa*, and the beds are named after the first of these.

One of the most striking phenomena of the period of the greatest submergence in the Christiania fjord is the well-known coral reef, so carefully described by M. Sars, consisting of masses of the deep-water coral *Lophohelia prolifera*, Linn., which, in a dead but well-preserved condition, occur at Dröbak, south of Christiania, covering the sea-bottom at levels of 60 metres below the surface, and they are also found over an area of about 100 square kilom. to a height of 30 m. above the sea. Associated with the coral is the giant form of *Lima excavata*, Fabr. Both the coral and shell are now found living in the Norwegian fjords at depths of 100–300 fathoms, and it is probable that they existed in the Christiania fjord at a depth of not less than 150 metres, when the climate was not very

different from the present and the margin of the land-ice yet stood before Mjösen and Randsfjord.

The upper marine boundary at Christiania is about 216 metres (708 feet) above the sea-level, and the maximum of the subsidence occurred when the ice had retreated behind the epiglacial station, and this morainic dam appears to have barred the further extension inland of the sea, for behind it no marine deposits have been met with. The further melting back of the ice took place when the period of elevation had set in, and the valleys then became fresh-water lakes.

The full extent of the depression of the land at the time of the last ice-sheet is unknown; that portion of it, from the time of the outer ra to the epiglacial moraine, which can be approximately ascertained, probably represents only the smaller half of the subsidence. Shortly before the formation of the outer ra, the land was probably about the same level in relation to the sea as now; during its deposition the land sank to about 100–125 metres lower than at present, and at this period the older and newer Yoldia-clays and the lower Arca-clay were deposited. When the moraines of the inner or second ra were formed, the subsidence reached to 185 m. at Hougen, and at the third morainic station in the Christiania valley to about 200 m.; in front of these moraines the newer Arca-clay and the Portlandia-clay were laid down. At the time of the epiglacial moraines, when the subsidence ceased, the land south of Lake Mjösen had sunk about 240 m. (787 feet).

The climate of the Christiania region during the long period of subsidence changed from a high Arctic character to that of a boreal Arctic. At the time of the lower Yoldia-clay the average temperature was probably —6°– —9° C., similar to that of the Kara Sea; in the upper Yoldia-clay period, —4° C., like that of the sea round Nova Zembla; whilst at the time of the upper Arca-clay it had risen to 2° C., similar to that of West Finmark. At the close of the subsidence, during the formation of the epiglacial moraine, the climate probably differed but little from the present one.

The author proposes to designate the whole interval of the late glacial subsidence, which may well have comprised some thousands of years, the Christiania period, and he considers it to correspond with the Champlain period of North America.

II. *The Late Glacial Shell Beds and Clay Deposits formed during the Elevation of the Land.*

The very highest occurrences of late Glacial marine shells in the Christiania district were discovered by Mr. P. Öyen in littoral sands and gravels at Grefsen and Årvold, near Christiania, at levels of 203–208 metres above the sea, only a short distance below the maximum marine margin, which here is 216–218 metres. The shells belong to but few species; they include *Mytilus edulis*, *Macoma baltica*, *Mya truncata*, *Saxicava pholadis*, etc. The shells occur for the most part as casts or impressions; the beds are of a very different character from those at lower levels, and they may probably

be referred to the concluding part of the period of subsidence rather than to that of elevation. They are overlaid by gravels with numerous large boulders.

The higher, late Glacial shell beds in the vicinity of Christiania have long been known through the descriptions given by Keilhau, M. Sars, and Kjerulf. They consist, for the most part, of sands and pebbly gravels, crowded with fragments of broken shells, and in some places entire forms, belonging to the littoral or the highest part of the laminarian zone, which lived at depths not more than about 10 metres. They are known as the Mya-beds, from *Mya truncata*, one of the most characteristic forms; *Mytilus edulis* is also common; other species are *Cyprina islandica*, *Macoma baltica*, *Littorina littorea*, etc. In the southern part of Smålenene, to the south-east of Christiania, the upper Mya-beds contain 23 species of mollusca, 17 of which are Arctic and 6 boreal forms. The beds are situated at levels of 130–155 metres above the sea. In the lower Mya-beds, near Fredrikshald in the same district, 45 species of mollusca are known; of these 22 species are Arctic, 20 boreal, and 3 Lusitanian. In the same beds near Christiania, at 110–140 m. above the sea, 26 species of mollusca are known, 9 of which are Arctic, 13 boreal, and 4 Lusitanian.

A series of fossiliferous clay-beds, corresponding with the Mya-beds of the higher or early stages of the uplift, are found in the Christiania valley, and are known as the Mytilus-Cyprina-clays. At Grorud lower and younger clays occur, containing a number of southern (Lusitanian) species, including *Pholas candida*, *Cardium edule*, etc.; they are known as the oldest Cardium-clays.

From differences in the character of the shell beds in various localities, at levels corresponding to the same percentage of the total uplift, it would appear that the elevation of the region began earlier in the southern peripheral portions once covered with the ice-sheet, and continued in advance of that of the central portions, at least during the first half of the uplift.

III. *The Post-Glacial Shell Beds and Clay Deposits of the Christiania Region.*

Shell beds, lower and younger than the Mya-beds, corresponding to the middle period of the uplift, that is, from 40 to 66 per cent. of the total elevation of the land, are somewhat rare, and it is therefore difficult to fix a definite boundary between the late Glacial and the post-Glacial deposits, but it is probably situated at a level of something over half (50–60 per cent.) of the total uplift.

At Bryn, near Christiania, there is a younger Cardium-clay, corresponding to the middle period of the uplift, the fauna of which has been described by Crosskey & Robertson. It contains 15 species of mollusca, only 1 of which is Arctic, whilst 7 are boreal, and 7 Lusitanian species. The beds are now 76–85 m. above the sea, and the shells probably lived at depths of 20–30 m. The highest marine shore-line here is 215 metres.

During the later stages of the uplift of the land, beds of shells

and clay deposits were successively formed at lower levels; the fauna in these varies in the direction of a gradual increase of boreal and Lusitanian species and the disappearance of Arctic forms. Lists of species found at different localities are given, and the following grouping has been adopted by the author.

The uppermost, Ostrea-beds, which come next below the level of the Cardium-clay, contain 77 species of mollusca, of which $\frac{2}{11}$ are Arctic, $\frac{6}{11}$ boreal, and $\frac{3}{11}$ Lusitanian, indicating a climate nearly similar to the present. In contemporaneous clays at Jarlsberg there are remains of hazel, oak, *Rubus*, *Viola*, etc.

Next younger are the upper Tapes-beds, which are strikingly developed at Dröbak to the south of Christiania. The fauna of these beds has been carefully worked out by Sars and others. With few exceptions the species are the same as those in the Ostrea-beds. The commoner genera are *Tapes*, *Ostrea*, *Mytilus*, *Astarte*, *Cardium*, and *Littorina*. Altogether 216 species of mollusca have been recorded from these beds, of which 34 are Arctic, 89 boreal, and 93 Lusitanian, or in the proportions respectively of $\frac{1}{7}$, $\frac{3}{7}$, $\frac{3}{7}$. The species indicate a climate notably milder than at the beginning of the post-Glacial period, and probably even milder than the present. Shell beds corresponding to these Tapes-deposits are known in Sweden, along the shores of the Cattegat, in Jutland, also along the Norwegian coast, west of the Christiania fjord. At Jæderen, near Stavanger, refuse shell heaps or 'kitchen middens,' of the older Neolithic age, have been found at levels of 18 metres above the sea, showing that the flint folk lived in Norway during the Tapes-period. These beds have also been traced as far north as Vardö, where they contained 26 species of mollusca, of which 3 only are Arctic, 11 boreal, and 12 Lusitanian. A number of these last are now extinct in that region, which confirms the view as to the mildness of the climate in the Tapes-period.

Contemporaneous with the littoral Tapes-beds, there is in the Christiania valley a widespread clay deposit, probably laid down at depths of 15–40 metres, known as the Isocardia-clay, after its leading fossil, *Isocardia cor*, Linn. Eighty-two species of mollusca, mostly the same as those in the Tapes-beds, are recorded from it, together with remains of oak, fir, birch, and hazel.

Corresponding with the final stages of the post-Glacial elevation, there are a number of littoral shell beds known as the lower Tapes-beds, spread over the Christiania region at levels of 1–13 metres above the sea, and associated with them are clay-deposits, named the Scrobicularia-clays. At Barholmen, near Dröbak, these beds have yielded 124 species of mollusca, of which 18 are Arctic, 53 boreal, and 53 Lusitanian; thus showing an important immigration of southern forms during their deposition. At Brevik numerous species of foraminifera, echinoderms, entomostraca, etc., were determined from the lower Tapes-beds by Münster, whose list is quoted.

The Scrobicularia-clays are the lowest and latest post-Glacial shell beds in the Christiania region; they are now met with at levels

from slightly above to slightly below the sea. The beds are often brought to light in the excavations for buildings in the lower part of the city of Christiania. The most characteristic species is *Scrobicularia piperata*, a southern form which extends to the Mediterranean. Though still living off the west coast of Norway at depths of 0–8 metres, it no longer inhabits the Christiania fjord.

The total number of species in this youngest post-Glacial deposit, including the Scrobicularia-clays, is 245, of which 34 are Arctic, 102 boreal, and 109 Lusitanian species, or approximately in the proportions of $\frac{1}{7}$, $\frac{3}{7}$, $\frac{3}{7}$. The Lusitanian or southern element has distinctly increased in these beds, both by the introduction of new species and the predominance of others.

The *living* molluscan fauna of the Christiania fjord comprises 268 species, as against 255 species in the post-Glacial fauna; 210 species are common to both. Forty-five post-Glacial species have not as yet been met with living in the Christiania fjord, whilst 53 species now living in the fjord are not known in the post-Glacial beds of the region. A significant number of the Lusitanian forms of the post-Glacial beds have disappeared from the fjord and the nearest portions of the Norwegian coast, even after the land had been elevated to its present level. Amongst those in the existing fauna and not known in the post-Glacial deposits, there are several Arctic species which apparently have migrated to Scandinavia from the northern part of the American continent, where they still live; they are unknown in the Polar Sea to the north of Asia. This shifting of species shows that the boreal element is more prominent in the present fauna of the fjord than during the latest post-Glacial time, when the climate also seems to have been 2° C. warmer than at present.

There is no conclusive evidence in the Christiania district of a depression corresponding to the *Ancylus* or *Littorina* depression of the Baltic basin. In some localities a deposit of warm, comparatively shallow-water, post-Glacial clay (Isocardia-clay as a rule) rests unconformably, with a sharply defined junction-plane, on the cold deep-water Arca-clay, from the upper surface of which boulders project to which balani and oysters are attached, indicating that this surface cannot have been elevated and exposed to atmospheric erosion before the post-Glacial clay was laid down over it. Some of the recorded occurrences of clays of deep-water origin intervening between shallow-water shelly sands may have originated by the sliding down of clay-beds from higher levels of valley slopes, instances of which are not uncommon.

At the end of the book a table is given showing the changes of level, the variations in the molluscan fauna, and in the climate of the Christiania region from the Yoldia-clay of the ra period to the present, and this is followed by a list of species of all the known shell-bearing mollusca in the late Glacial and post-Glacial deposits, showing their distribution in the different periods.

In concluding this notice we desire to call attention to the admirable way in which the mollusca, so fully treated in the work,

have been illustrated. To awaken the interest of the student and stimulate fresh observations, the author has given in the nineteen plates, and partly also in the text, figures of all the species of molluscа hitherto known from the late Glacial and post-Glacial deposits of the Christiania region, and these have been excellently and faithfully drawn by Froken Sigfrid Bergh, the artist to the University of Christiania. The geologists of this country and elsewhere, to whom Norse is an unknown tongue, will also much appreciate the full summary in English of the contents of the work, extending over 35 pages, which the author has prepared. G. J. H.

REPORTS AND PROCEEDINGS.

Geological Society of London.

I.—April 30th, 1902.—Professor Charles Lapworth, LL.D., F.R.S., President, in the Chair.

Mr. J. E. Marr exhibited some specimens from a metamorphosed metalliferous vein several inches wide, which he had discovered in the basic andesites near the Shap Granite, in a quarry close to the high road, north of the spot where it crosses Longfell Gill.

The minerals of the vein include quartz, calcite, garnet, epidote, hornblende, galena, iron-pyrites, and copper-pyrites. Some of the garnets are about an inch in diameter. The epidote and the hornblende tend to form distinct bands on the margin of the vein. The other metamorphic phenomena recall those described by the exhibitor and Mr. Alfred Harker, in the case of large vesicles occurring in the same rocks.

The specimens are of interest as showing :—

(i) The existence of metalliferous veins in Ordovician rocks which have been formed in pre-Carboniferous times, for the Shap Granite which has produced the alteration is itself pre-Carboniferous.

(ii) The alteration of a metalliferous vein of complex composition by pyrometamorphism, an occurrence which the exhibitor believed had not previously been recorded.

(iii) The possibility that some of the highly crystalline rocks of a complex of regionally metamorphosed rocks may owe their characters to hydrothermal action having formed veins along the parallel divisional planes of pre-existing rocks, these veins having been subsequently altered by pyrometamorphism.

The following communications were read :—

1. "The Origin and Associations of the Jaspers of South-Eastern Anglesey." By Edward Greenly, Esq., F.G.S.

Red jasper and jaspery phyllite are widely distributed in the southern and south-eastern parts of Anglesey, in the districts of Newborough, Pentraeth, and Beaumaris. They are associated with limestones, diabases, serpentines, and with grits and shales. They have been much modified by earth-movements, which have produced brecciated and schistose structures; but where original structures have survived, the true relations of the rocks can often be seen. The diabases have the same characters as the pillowy and variolitic rocks so often associated with radiolarian cherts and jaspers in many

parts of the world, and at several different geological horizons; and the relationships of the jaspers and igneous rocks resemble those seen in the radiolarian cherts of Southern Scotland. It is inferred that the jaspers are altered radiolarian cherts. The evidence for the age of the group is incomplete. There is not sufficient evidence to refer it to the Arenig Series, and it is possible that it belongs to an altogether different period. Its relation to the crystalline schists of the region is obscured by conflicting evidence: one chain of reasoning leads to the view that the group is older than the schists, and has been involved in their metamorphism; while another gives strong reason for supposing that it is of later date.

2. "The Mineralogical Constitution of the Finer Material of the Bunter Pebble-Bed in the West of England." By Herbert Henry Thomas, Esq., B.A., F.G.S.

Specimens were collected at intervals, from Budleigh Salterton, in Devon, to Fitzhead near Milverton, in Somerset, and other sands, for comparison, were taken from the red rocks above and below. After treatment with acids, to remove iron-oxides, the sands were separated by heavy liquids into three parts:—

(*a*) Heavy residue: specific gravity exceeding 2·8.
(*b*) The bulk of the quartz.
(*c*) The lighter part, with most of the alkali-felspar.

The sands, on the whole, contain a very small percentage of minerals with a specific gravity of more than 2·8; while the proportion of material over, to that under, 2·58 is about 70 or 80 to 30 or 20 per cent. A list and description of twenty minerals found in the sands is given, with, in some instances, the chief characters by which they were identified. The compound grains include felsite, quartzite, chert, shimmer-aggregates, leucoxene, and other decomposition-products. The gradual decrease in the percentage of heavy minerals from Budleigh Salterton to Uffculm indicates the carriage of sediment by a southerly current, and this view is strengthened by the decrease in staurolite and a gradual diminution in the size of the tourmaline-grains. The increase in proportion of heavy grains from Uffculm to Milverton, and the further decline northward, together with the incoming of an assemblage of minerals markedly different from the normal southerly type, indicates an additional source of supply, perhaps a westerly current. The mass of material seems to have been furnished by a highly metamorphosed area, differing widely in its character from any now exposed in the south-west of England. The most probable source of much of the material is the Armorican massif of Triassic times.

3. "Revision of the Phyllocarida from the Chemung and Waverly Groups of Pennsylvania." By Professor Charles Emerson Beecher, Ph.D., F.C.G.S.

The specimens described in the paper, as well as those on which the original descriptions were based, were all obtained in the vicinity of Warren, Philadelphia. The chief horizon is in the shale-beds of the Upper Chemung Group, about 50 feet above mean water-level

in the Allegheny River. The deposits are called by the writer the 'Phyllocarid Beds.' Additions and emendations to the original diagnoses of the following genera and species are given: *Echinocaris socialis*, Beecher; *Tropidocaris*, *Tr. bicarinata*, Beecher, *Tr. alternata*, Beecher; *Elymocaris*, *E. siliqua*, Beecher; and two new species of *Echinocaris* are described.

II.—May 14th, 1902.—Professor Charles Lapworth, LL.D., F.R.S., President, in the Chair.

The President referred in feeling terms to the recent calamitous occurrences in the West Indies, and to the geological interest of the phenomena. The Council had been considering in what way they could best give expression to the sympathy of the Fellows, both with our own Colonies and with their French neighbours, and had requested Sir Archibald Geikie and himself to act as they thought best in the matter.

Professor Boyd Dawkins moved that the Fellows express their sympathy with the sufferers in the two islands, and approve the action taken by the Council.

Mr. H. W. Monckton seconded the motion, which was carried.

The following communications were read:—

1. "On Pliocene Glacio-Fluviatile Conglomerates in Subalpine France and Switzerland." By Charles S. Du Riche Preller, M.A., Ph.D., A.M.I.C.E., M.I.E.E., F.G.S.

In a paper read before the Society in 1896 the author described a variety of Deckenschotter deposits above, near, and below Zurich, which, occurring both on the hills and at low levels of the valleys of that district, tended to the conclusion that at the time of their formation, towards the end of the Pliocene Period, the principal valleys and lake-basins of Subalpine Switzerland were already eroded approximately to their present depth.

Further examination has, however, led him to recognize that the low-level deposits, although in many respects not unlike Deckenschotter, are the products of the younger or Pleistocene glaciation, and that only the deposits *in situ* on the ridge of the hills can be referred to the Pliocene glaciation of the Alps.

In the present paper the author describes a number of further deposits of typical Deckenschotter conglomerate recently examined in the Aare and Rhine valleys, near the confluence of those rivers, and shows that these, in conjunction with the Deckenschotter deposits of the Zurich district, indicate the almost unbroken outline of a Subalpine Deckenschotter cone, which extended from the base of the Alps in a north-westerly direction over a distance of about 25 miles, and was formed by the waters of the retreating Rhine (Western) glacier and its affluents on a molasse plateau, the upper and lower ends of which were at the contours of 900 metres and 500 metres respectively.

He further describes a series of Deckenschotter deposits examined in the Rhone Valley between Lausanne and Lyons, including the

extensive plateau of the Dombes, east and north of Lyons, composed of marine marl overlain by the characteristic conglomérat ferrugineux, which some French geologists still regard as pre-Glacial and others as Quaternary, but which is typical Deckenschotter, and in the full acceptation of the term an alluvion des plateaux. The deposits thus described afford proof of the existence, in Upper Pliocene times, of an extensive alluvial cone about 100 miles in length, which reached from Lausanne (probably even from the base of the Alps) to Lyons, and was formed by the waters of the retreating Rhone and Arve glaciers on a Molasse-and-marl plateau, the altitude of which above sea-level was 800 metres near Lausanne and 300 metres near Lyons.

From this concurrent evidence in Northern Switzerland and in the Rhone Valley, the author is led to conclude—

(1) That at the time of the deposition of those alluvial cones, the principal Subalpine valleys and lake-basins could not as yet have existed in their present form or depth, and must have been from 100 to 200 and 400 metres higher; and

(2) That the Subalpine valleys were eroded to their present depth in the course of the inter-Glacial Period—now recognized to have been of very long duration—between the Pliocene and the Middle Pleistocene (or maximum) glaciations, and that the Subalpine lake-basins were formed in the same period by the contemporaneous action of fluviatile erosion and of a zonal settling along the base of the Alps after these had been raised by horizontal pressure.

2. "Overthrusts and other Disturbances in the Braysdown Colliery (Somerset), and the Bearing of these Phenomena upon the Effects of Overthrust Faults in the Somerset Coalfield in general." By Frederick Anthony Steart, Esq. (Communicated by Horace B. Woodward, Esq., F.R.S., F.G.S.)

This coalfield, although covered by comparatively undisturbed Secondary rocks, is in part the most disturbed and contorted of those known and worked in the United Kingdom. It is seldom, in some parts of it, that one sees 200 yards of coal without a fault or other disturbance. The 'Radstock Seams' of the Upper Coal-measures at Radstock are traversed by a huge 'overlap fault,' which thrusts them forward for a great distance; this runs nearly east and west, and has parallel to it two smaller overthrusts. In one of them the coal at first dips towards the thrust, then it thickens from 2 to 6 or 8 feet, next it becomes inverted, and eventually regains its former character. The continuity of the coal has been proved in the case of three of the coal-veins. As there is practically the same sequence of strata on both sides of the fault, it is concluded that the 'overthrusts' did not take place till all the coal-seams of the Radstock Series had been deposited. The areas of 'dead ground,' sometimes considered to be wash-outs, are probably also the result of movement. The areas occur near faults, frequently take a course parallel to overthrust faults, and at their margins the coals are often reduplicated. 'Dead ground' is usually found

only in those seams which lie on a floor of soft black shale, and sometimes, instead of dead ground, there are large areas with very thin coal. The flat roofs of coal-seams in the dead ground are invariably striated. The author's theory is that all these effects have been caused by the gradually increasing movement of the strata from the top seam or 'Great Vein' to the bottom seam or 'Bull Vein.' The coal-seams nearly always thin from their undersides upward, as though the floor had moved farther, or at a greater rate, than the roof.

III.—May 28th, 1902.—Professor Charles Lapworth, LL.D., F.R.S., President, in the Chair.

The President reported that in consonance with the resolution passed at the previous meeting of the Fellows, he and Sir Archibald Geikie had forwarded a letter to the French Minister of the Colonies and H.M. Secretary of State for the Colonies, expressive of the sympathy of the Geological Society with the sufferers from the volcanic catastrophes in Martinique and St. Vincent.

The Secretary read the following letter regarding the recent fall of volcanic ash in Barbados, and reported that the thanks of the Council had been conveyed to the writer:—

"Imperial Agricultural Department for the West Indies, Barbados.
9th May, 1902.

"Dear Sir,—I am sending you by this mail a small quantity of the volcanic ash that fell at Barbados soon after the volcanic eruption at St. Vincent on Wednesday last. I am also sending you newspaper reports, and you will obtain practically all particulars from them. There is a note about the ash in the *Agricultural News*, giving an estimate of the quantity per acre that fell in this island. It is singular that the circumstances correspond so exactly with what took place in 1812. Fortunately, within four hours after the fall of the ashes, we have had drenching showers which have, to a great extent, washed the ashes from the roofs of the dwellings and from vegetation, and also laid the dust which during yesterday was most trying and uncomfortable. The roads are still covered with a sandy coating, which is not at all muddy or sticky. Naturally the chemical composition of the ash is of great interest to the planters, as it may have an appreciable effect on next year's crops. The old canes have nearly all been reaped, and the young canes are in such a condition that they should largely benefit by any fertilizing properties that may be in the ash. In the case of the ash that fell in 1812, Davy is said to have found it to contain silex, alumina, oxide of iron, and oxide of manganese. I noticed that the ash at first was rather coarse and of a brownish colour, then it became slightly redder, while the final deposits consisted of a whitish-grey, impalpable powder. I shall send you any further particulars that may come to hand.—With kind wishes, believe me,

"Sincerely yours,
(Signed) D. Morris.

"The Secretary, Geological Society,
Burlington House, Piccadilly, London."

Professor W. Boyd Dawkins exhibited a series of photographs and specimens of sand-worn pebbles collected by Lady Constance Knox in New Zealand. The district in which the specimens occur is near the coast of North Island, in the neighbourhood of the River Waitotara, from a tableland about 250 feet above sea-level.

"On the tableland, above high cliffs, are rolling sand-dunes, which are continually shifting with every storm, and extend for several miles along the coast; among them are to be found interesting kitchen-middens. Directly inland from the sand-dunes is the district covered with sand-worn stones, extending over an area of some miles.

At first these stones are few and scattered, but they are found to increase in number as one approaches the Waitotara River. Projecting from the surface are masses of stratified rock, composed of shell-conglomerate: these also have been worn by the wind."

The following communications were read :—

1. "The Red Sandstone Rocks of Peel (Isle of Man)." By William Boyd Dawkins, M.A., D.Sc., F.R.S., F.G.S., Professor of Geology in Owens College (Victoria University), Manchester.

The Red Sandstone Series, ranging along the coast from Peel to Will's Strand, is faulted into the Ordovician massif of the Isle of Man. It has been referred to the Old Red Sandstone, the Calciferous Sandstone, the basement Carboniferous, and to the Permian. The series consists of red sandstones containing irregular conglomerates and breccias, more or less chemically altered, known in the Lake District as 'Brockram.' Sections at Ballagnane, Creg Malin, and at the Gob and Traie Fogog are described in detail; the rocks are classified, and their range to the north-east and inland is described. It is pointed out that the rocks are different in many respects from the basement Carboniferous rocks of Langness and elsewhere, and a list of the materials contained in the 'Brockrams' is given. All these materials have been derived from rocks similar to those which form the Lower Carboniferous Series in the Lake District, with the exception of one or two types which might belong to any other pebble beach. The fossiliferous pebbles in the rocks in question are described, and their fossil contents determined. The whole group of fossils is Lower Carboniferous and Ordivician, and centres mainly in the Carboniferous Limestone. A comparison is instituted with the Permian rocks of Barrowmouth, the Vale of Eden, and elsewhere. The rocks are much sheared and faulted: the planes of shearing intersect the bedding-planes, and divide the rock into lenticular and diamond-shaped masses, which are scored and slickensided. The earth-movement to which this is due took place in the interval between the latest Palæozoic and earliest Mesozoic deposits. The iron in the rocks was probably derived from the destruction of the Carboniferous shales.

2. "The Carboniferous, Permian, and Triassic Rocks under the Glacial Drift in the North of the Isle of Man." By William Boyd Dawkins, M.A., D.Sc., F.R.S., F.G.S., Professor of Geology in Owens College (Victoria University), Manchester.

The whole of the Isle of Man, north of a line drawn due west from Ramsey, is covered with a thick mantle of Glacial Drift. South of this line rises the ice-worn Ordovician massif. Six borings carried out under the advice of the author have elucidated the geological structure of the Drift-covered area. The borings at Lhen Moar, Ballawhane, Knock-e-Doony, Ballaghenny, and two at the Point of Ayre are described in detail, and the rocks classified. The first shows Carboniferous Limestone under Drift; the second and third, Trias, Permian, Yoredale, and Carboniferous Limestone; the fourth, Trias, Permian (thin), and Yoredale; the fifth and sixth, Trias, with gypsum and 76 feet of rock-salt. The rocks all dip in natural order

towards the north, and constitute a plateau of marine erosion sloping to the north and east, covered with Drift, which is in places not less than 450 feet thick.

3. "Note on a Preliminary Examination of the Ash that fell on Barbados, after the Eruption at St. Vincent (West Indies)." By John Smith Flett, M.A., D.Sc., F.R.S.E., F.G.S. With an Analysis of the Dust by William Pollard, M.A., D.Sc., F.G.S.

Two samples of the material were sent by Dr. D. Morris, of the Imperial Agricultural Department for the West Indies, to Professor J. W. Judd, who forwarded them to the Director of the Museum of Practical Geology. The fine grey powder is gritty to the touch, and it all passed through a sieve with 30 meshes to the inch. It contains plagioclase-felspar (generally idiomorphic labradorite) coated with a thin film of glass, hypersthene and monoclinic brownish augite, both frequently in perfect crystals, magnetite, apatite, possibly zircon, and fragments of a brown glass. Among the finest débris there is much felspar in the form of minute chips. The perfect crystalline form of many of the constituents of the dust and the small amount of glass adherent to them, indicate that at the time of projection the glassy magma must have been very fluid, and it must have been to a large extent wiped off the crystals by friction. From Dr. Morris's account the minerals of high specific gravity appear to have fallen first; the order being magnetite and pyroxenes first, next the felspars, and finally the glass threads and minute felspar débris. Dr. Pollard's analysis is as follows:—SiO_2=52·81, TiO_2 = ·95, Al_2O_3 = 18·79, Fe_2O_3 = 3·28, FeO = 4·58, MnO = ·28, (Co Ni) O = ·07, CaO = 9·58, MgO = 5·19, K_2O = ·60, Na_2O = 3·23, P_2O_5 = ·15, SO_3 = ·33, Cl = ·14, H_2O = ·37; total 100·35.

CORRESPONDENCE.

FIGURES OF *CAMPYLOPRION*, PLATE VIII.

Sir,—Owing to my not having had the opportunity to see proofs of illustrations for my article on *Campyloprion* in the April number of the Magazine, a slight error occurred in designating their scale of reduction. Figs. 1 and 2 of Plate VIII are reduced to about three-sevenths natural size, and Fig. 3 in the text is of the natural size. In the Explanation of Figures on p. 152, the fused teeth of *Campyloprion* are stated to be "supported at their bases by a band of calcified cartilage." This should be understood as an inference drawn from analogy, and not as implying that the basal parts of the segments in this genus or in *Edestus* are of calcified cartilage, when they have been well ascertained to consist of vasodentine.

C. R. Eastman.

Museum of Comparative Zoology,
Cambridge, Mass.

VON ZITTEL'S HISTORY OF GEOLOGY.

SIR,—I am one of those who in consequence of your notice in the April number at once sent for the translation of Von Zittel's History of Geology, etc. I read it with avidity, and can endorse all that was said about the book. Specially was I interested in the masterly manner in which the subject of metamorphism, the discussion on the Cambrian and Silurian systems, the *Eozoon Canadense*, the North-West Highlands of Scotland, and the unravelling of the Alpine strata were treated, with the various points still open for investigation.

There are, however, on p. 159, which contains statements as to the diameter of the planets, and on p. 168, where the thickness of the solid crust of the earth is dealt with, also on p. 300, where the shortening of the earth's radius is mentioned, figures given which I do not understand. The writer or the translator must have had some modulus of dimension in mind different from any of those stated in the text. It would be well before a second edition is produced that these points should be reconsidered.

The following are the clauses remarked upon :—

Page 159 : "Of the six planets that were known in early astrology, Mercury is nearest the sun in position, and has itself a diameter of 648 miles; Venus (diam. 1,613 miles) follows Mercury, then the Earth (diam. 1,719 miles), then Mars (diam. 909 miles), Jupiter (diam. 19,000 miles), and Saturn (diam. 16,675 miles). Herschel in 1780 discovered on the farther side of Saturn the planet Uranus with a diameter of about 8,000 miles, and Leverrier in 1846 discovered by mathematical calculation the outermost planet, Neptune, with four and a half times the diameter of the Earth."

The ordinary textbooks give—Mercury, 2,000 miles diameter; Venus, 7,600; Earth, 7,928; Mars, 4,430; Jupiter, 86,000; Saturn, 76,246; Uranus, 32,000; Neptune, 35,000.

Page 168 : "Hopkins calculated that the solid crust of the earth had a thickness of about $\frac{1}{4}$ or $\frac{1}{5}$ of the earth's diameter, that is, at least 172 to 215 geographical miles."

Page 300 : "Delesse had calculated 1,340 metres as the amount by which the earth's radius had already been shortened; in other words, the earth's crust in the course of the geological epochs had approached the earth's centre by a distance about equal to the height of Chimborazo or the Himalayas above sea-level."

THOMAS M. RICKMAN.

8, MONTAGUE STREET, RUSSELL SQUARE, W.C.
May 31, 1902.

THE LIMITS OF LEGITIMATE SPECULATION AT THE GEOLOGICAL SOCIETY.

SIR,—Early in 1900 I submitted to the Geological Society a short paper on Bala Lake and the rivers of North Wales, in which I attempted to show that the great valleys which run through North Wales from north-east to south-west had probably been

formed by earth-movements, and had produced a great effect upon the river-system. In the discussion which followed this view was severely criticized by Mr. Strahan, and was characterized by him as highly speculative.

A few months ago Mr. Strahan read at the Geological Society a paper on the rivers of South Wales; and in this he makes the suggestion, quite as if it were new, that the north-east to south-west valleys are due to earth-movements, and that the complications of the drainage system have been produced by these movements.

My paper was rejected by the Council[1] as too speculative: Mr. Strahan's has just been published in the Quarterly Journal.

To those Fellows who are not familiar with Burlington House, I commend a comparison of these two papers.

PHILIP LAKE.

MR. STRAHAN AND SOME ENGLISH RIVERS.

SIR,—In his suggestive paper "On the Origin of the River System of South Wales, etc.," in the recently published May number of the Quart. Journ. Geol. Soc., Mr. Strahan states (pp. 219–220) that "The [Chalk-] escarpment, in that part of it which extends from Dorset to the borders of Hertfordshire, diverges from the water-parting three times, namely, in the Vales of Wardour and Pewsey and in the valley of the Upper Thames. In *all* these cases, rivers rising in the low-lying Oolitic region flow eastward against the general run of the country, and make their way through the Chalk-escarpment to the Thames or Frome. The explanation did not escape Ramsay. *Their courses were initiated upon an eastward slope of Chalk, and the distance from their sources to the existing escarpment is a measure of the recession of the escarpment since the initiation.*"

With respect to this passage (in which the italics are mine) I should like to point out (1) that the river running eastward through the Vale of Pewsey does not rise "in the low-lying Oolitic region," but in a tract of Chalk and Upper Greensand to the east of and some 200 feet above it. (2) That inasmuch as the rivers traversing the Vales of Wardour and Pewsey follow the axes of minor east-west anticlinal folds, they are to be regarded rather as longitudinal, autogenetic branches of the north-south Salisbury Avon, than as primary, or consequent, eastward streams of the Upper Thames class. Unlike the Upper Thames, the Kennet–Thames, or the Frome, which follow the slopes of constructional troughs, these streams (i.e. the Nadder and Upper Avon) can only have come into existence after prolonged denudation of the folds on which they are situated. It is, therefore, scarcely probable that their present sources were determined by, or, indeed, are in any

[1] I owe it to the GEOLOGICAL MAGAZINE that the article subsequently saw the light (May and June, 1900).

way connected with the former position of the main, north-east to south-west escarpment of the Chalk.

It must be admitted that in dealing with the origin of the Southern English rivers Mr. Strahan shows generally a fine disregard for the principles of drainage development. H. C. Osborne White.

Wargrave, Berks.
May 21, 1902.

OBITUARY.

WILLIAM HENRY PENNING, F.G.S.

Born March 9, 1838. Died April 20, 1902.

Mr. Penning, who joined the Geological Survey in 1867, had in previous years qualified as an engineer under the late C. H. Gregory. During his official service he was engaged in the survey of portions of Essex, Hertfordshire, Suffolk, Cambridgeshire, and Lincolnshire, and he was joint author with Mr. Whitaker and others of "The Geology of the North-Western Part of Essex, etc." (1878), and with Mr. Jukes-Browne of "The Geology of the Neighbourhood of Cambridge" (1881). He also contributed to "The Geology of the Country around Lincoln" (1888), by Mr. Ussher and others, the memoir being published after he had retired from the Geological Survey in 1882 through ill-health. On this account he spent some time in South Africa, and, regaining health, he was enabled to communicate to the Geological Society of London papers on the high-level coalfields of South Africa, on the goldfields of Lydenburg and De Kaap, and on the geology of the Southern Transvaal. A previous communication by him dealt with the physical geology of East Anglia during the Glacial Period. Mr. Penning was author of a "Text-Book of Field Geology" (1876, second edition 1879) and of "Engineering Geology" (1880).

JOHN CLAVELL MANSEL-PLEYDELL, F.L.S., F.G.S.

Born 1817. Died May 3, 1902.

In the death of Mr. Mansel-Pleydell, of Whatcombe, Dorset, geological science has lost an energetic and enthusiastic worker, one who in the widest sense was a naturalist, for he was intimately acquainted with the plants, the mollusca, and the birds of his native county, and had published separate volumes on these subjects. The antiquities of Dorset had likewise engaged his attention, while as a Magistrate, as a member of the County Council, and as High Sheriff (in 1875) he had rendered distinguished local services. He was educated at St. John's College, Cambridge, and on the death of his father in 1863 he succeeded to the family estates, which included land in the Isle of Purbeck. Here he had fine opportunities for geological research, and the Kimeridge Clay in particular yielded to him many saurian remains, some of which were described by Owen and J. W. Hulke. In 1873 he contributed to the Geological